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Sky and TELESCOPE

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CONTENTS

COVER: An aerial view of Mount Wilson Observatory, near Pasadena, Calif. At the left are the 150- and 60-foot solar tower telescopes, and the horizontal Snow solar telescope. In the middle is the dome of the 60-inch reflector, and left of this the 6-inch refractor. At the right, the largest dome houses the 100-inch Hooker reflector; in front of this is the shed housing the 50-foot stellar interferometer. Mount Wilson and Palomar Observatories photograph. (See the story on this page.)

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Fifty Years at Mount Wilson

MOUNT WILSON Observatory is passing its 50th anniversary in 1954. The achievements of its 60- and 100-inch telescopes on galaxies and stars may tend to obscure the fact that solar research has always been an important activity on Mt. Wilson, as the tower telescopes on the front cover picture testify. In fact, the observatory owes its existence to the need expressed in 1902 by S. P. Langley, of the Smithsonian Institution, for a mountain observatory for studying variations in the solar constant.

According to George Ellery Hale's first annual "Report of Director of the Solar Observatory, Mount Wilson, California," occupation of Mt. Wilson began February 29, 1904. By the summer of that year a grant from the Carnegie Institution had made possible the transfer of the Snow telescope from Yerkes Observatory in Wisconsin. In its first year on the mountain, this telescope took direct photographs of the sun, spectroheliograms, spectra of sunspots and flocculi, and high-dispersion grating spectra of stars.

In this far-seeing first report, Hale defined the original purposes of the observatory in words that outlined the striking achievements that were to come:

(1) The investigation of the sun *(a)* as a typical star, in connection with the study of stellar evolution; *(b)* as the central body of the solar system, with special reference to possible changes in the intensity of its heat radiation, such as might influence the conditions of life upon the earth.

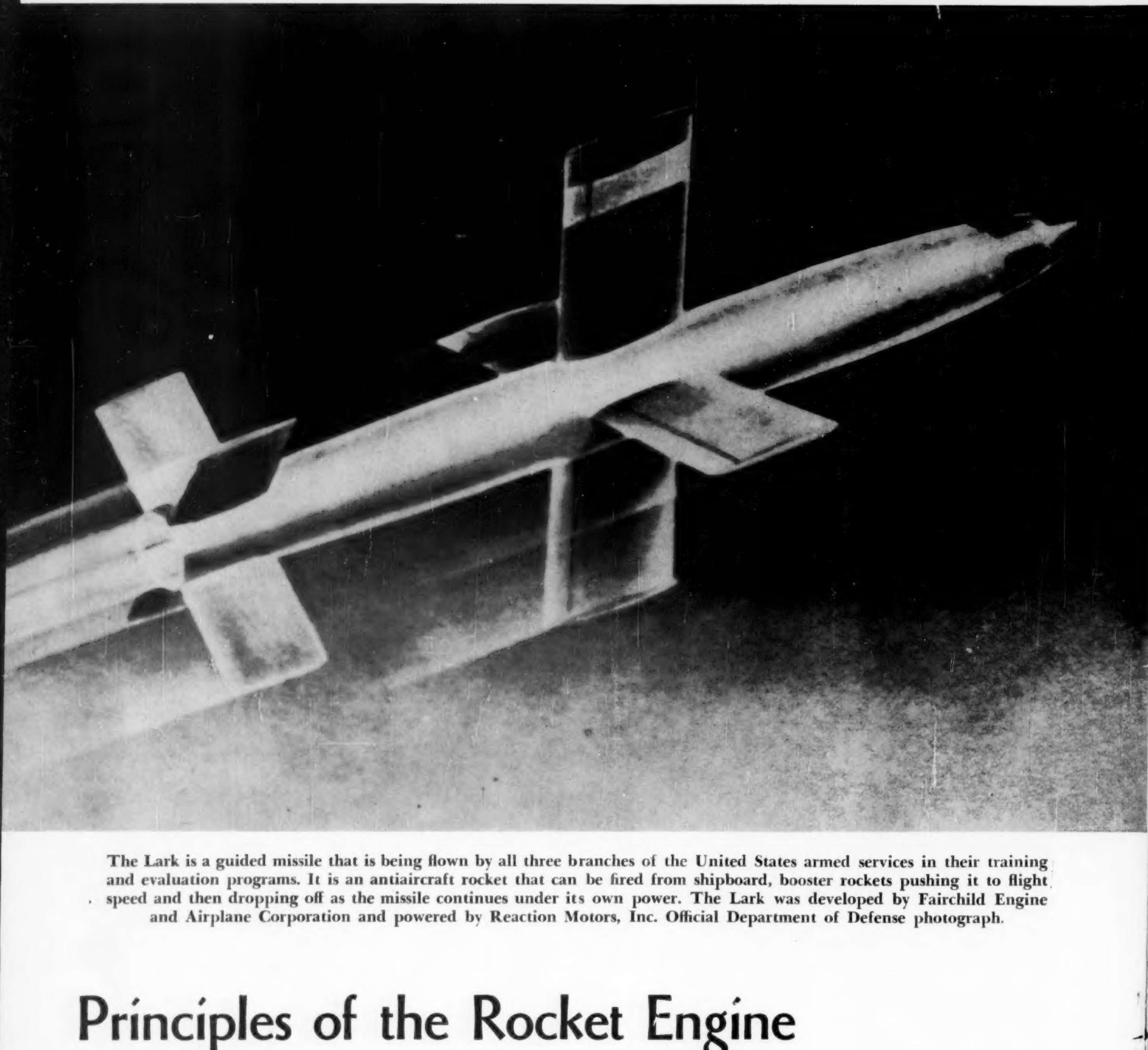
(2) The choice of an effective mode of attack, involving *(a)* the application of new methods in solar research; *(b)* the investigation of stellar and nebular phenomena, especially such as are not within the reach of existing instruments; and *(c)* the interpretation of these celestial phenomena by means of laboratory experiments.

(3) The design and construction of a large reflecting telescope and of new types of instruments peculiarly adapted for the purposes in view, with special reference to the possibilities of research through the study of celestial objects under laboratory conditions.

(4) The accomplishment of the foregoing purposes at a site where the atmospheric conditions have been shown to be exceptionally favorable: Mount Wilson (5,886 feet), in southern California (lat. +34° 13′ 26″, long. W. 118° 3′ 40″).

(5) The furtherance of international

(Continued on page 61)



The Lark is a guided missile that is being flown by all three branches of the United States armed services in their training and evaluation programs. It is an antiaircraft rocket that can be fired from shipboard, booster rockets pushing it to flight speed and then dropping off as the missile continues under its own power. The Lark was developed by Fairchild Engine and Airplane Corporation and powered by Reaction Motors, Inc. Official Department of Defense photograph.

Principles of the Rocket Engine

FREDERICK I. ORDWAY, *American Astronautical Society*

THE ROCKET has been around for a long time—at least 700 years—for the Chinese used solid-propellant "fire-arrow rockets" to repel invaders back in the 13th century. A much shorter period has elapsed, however, since Sir Isaac Newton found the all-important reaction principle upon which the rocket is based. It was even more recently that the implications of his famous third law became apparent to the rocket investigator.

Man first experimented with modern-type rockets because he realized that they offered the only possible means he would ever have of attaining space travel. Ziolkovsky, Esnault-Pelterie, Oberth in Europe, and Goddard in America, were among the true pioneers of modern rocketry. In the early part of the 20th century they anticipated, in one way or another, many if not most of the present-day rocket problems. As their calculations and experiments progressed, they more fully understood that the rocket was not only a means to carry scientific instruments to extreme altitudes and velocities, but that man could eventually achieve his age-old dream, the conquest of space.

The validity of the conclusions of these pioneer scientists was supported by intense World War II rocket research in Germany and elsewhere. Challenging developments began to appear upon the scientific horizon, bringing a new, unconventional type of propulsion out of the basement laboratory and Sunday-afternoon experiment stage, to a point where it astounded the military and transportation worlds. Before long, modern rocketry, having shattered all previous piloted and unpiloted speed and altitude records, could boast of a tremendous impact on our technological civilization. Thus the world, with a shelf already stocked with scientific wonders, has added perhaps the most challenging of all, the rocket.

The rocket engine might be considered an extremely complicated device and at the same time extremely simple. An opinion would depend on whether one

talked to the rocket engineer or the theoretical physicist. The former has to work with engines with weights figured in only hundreds of pounds that produce hundreds of thousands of horsepower, that create 4,000 to 5,000 mile-per-hour exhaust velocities and 5,000° F. combustion temperatures, and that have to be supplied with 10, 25, 50, or more gallons of propellants per second. The physicist, on the other hand, could talk of simplicity itself: no reciprocating parts, no complicated ignition system, easy-to-understand operation. By merely explaining basic principles, the latter scientist would appear to be correct in his view. As it turns out, both the engineer and the theoretician are correct. The rocket is as simple as it is complicated.

Mention has already been made of Newton's third law of motion, "to every action there is always an equal and opposite reaction." Until very recent years this was probably the law of Newton least used in practical applications, and then it was often badly employed. The "reaction" to an "action" was formerly thought of as at best a nuisance, as in the recoil of a rifle.

The third law is the key to rocket power. Here the reaction is put to work. The rocket is a jet-propelled device, deriving propulsive power from the reaction force produced by rapidly moving exhaust matter. The reaction equals the force which expels the matter, according to the law; let us see what this means.

Imagine, for a moment, that friction does not exist. Suppose a 150-pound man were to leap from a stationary 150-pound raft. The raft would kick back with the same speed as the man leaped forward. If the man weighed 300 pounds, the velocity of the raft would double that of the leaping man. The same principle applies to the cannon—the heavier the shell, the greater the recoil.

For a closer analogy to the rocket, assume that the man loads his raft with rocks. Instead of leaping off, he tosses them out over the stern, and the raft moves. The raft recoils to the thrust generated by throwing out or expelling matter. The more matter that is expelled out the rear, and the faster it is discharged, the greater will be the raft's forward velocity. The quantity and velocity of ejected matter are all-important keys to the performance of any reaction-propelled object.

A true rocket expels not rocks but microscopic particles, formed by the combustion of solid or liquid propellants. It has been discovered that it is far better to eject matter in very small pieces rather than in large hunks. The particles are discharged at high velocity through a jet nozzle which directs the exhaust, so that maximum thrust is obtained.

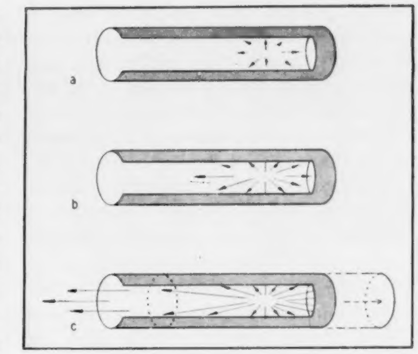


Fig. 1. How the reaction from expanding gas propels a rocket is illustrated here. As the gas escapes through the orifice at the left, the cylinder is forced to move to the right.

The diagram (Fig. 1) shows what occurs when propellants are burned in a cylindrical combustion chamber. The gases expand, as seen in Fig. 1b, exerting pressure on all parts of the chamber. The pressure-unbalance between its open and closed ends causes the chamber to begin to move in the direction opposite to that of the outrushing jet. As long as the reaction force continues and the exhaust can escape, the chamber will be accelerated in the direction indicated in 1c. The thrust generated will be transferred from the motor to the airframe on which it is mounted.

As the propellants are burnt up, the rocket vehicle becomes lighter, and its acceleration increases. It makes no difference what happens to the exhaust particles (or to the rocks from the raft) after they have been expelled; their work has been done. Thus the theoretical operation of the rocket is independent of external conditions; it would operate in the upper atmosphere or in interplanetary space. Indeed, air acts only as a drag on the rocket. We must distinguish here between true rockets, just described, and jet aircraft engines, which use air to support combustion of the fuel, and to add mass to the ejected exhaust stream. Both types, jet and rocket, operate by the reaction principle, however.

There are two distinct types of rockets, depending on whether solid or liquid fuel is used to produce the exhaust. Solid-propellant rockets, like the one shown schematically in Fig. 2a, are relatively simple, have no moving parts, and can be stored, transported, and fired with a minimum of difficulty. The propellant, a powder, is carried in the combustion chamber; once such a rocket is ignited it can not be turned off. This lack of flexibility is one of the main drawbacks of the solid-propellant engine.

The limitation is overcome in the liquid-propellant engine, which may be turned on and off by properly controlling the flow of fuel and oxidizer from the propellant tanks to the combustion chamber. But this is not the only advantage of liquid rockets.

It was early recognized by rocket investigators that liquid propellants generally contain more energy per unit weight than solid propellants. Their specific impulse is higher, that is, the number of pounds of thrust delivered per second for each pound of propellant used. Calculations show that rocket engines requiring long firing times and high energy operate more efficiently on liquids than on solids. The solid type is better suited to quick-firing JATO booster units (Jet Assisted Take Off rockets used to launch heavily loaded airplanes), to small missiles, and to forward-firing aircraft rockets.

In a liquid-propellant rocket engine a fuel is generally burnt in the presence of an oxidizer, yielding heat. This is called a bipropellant type of propulsive unit. (There is also a monopropellant type, where the fuel and oxidizer are combined in the same substance.) The two propellants are fed under pressure through an injector assembly to the combustion chamber (Fig. 2b). As the fuel burns, the expanding combustion gases maintain a pressure differential between the chamber and its surroundings, and this provides the thrust that propels the missile or aircraft. Obviously, the lower the outside pressure, the greater this pres-

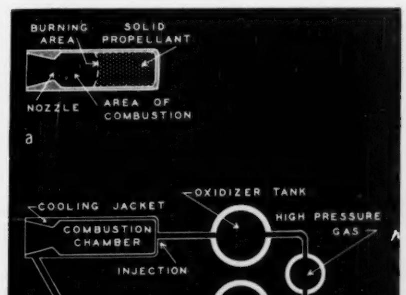


Fig. 2. Three types of rocket engine: a, simple solid-propellant type; b, bipropellant, with high-pressure feed; c, turbopump, with a hydrogen peroxide turbine to pump the fuels.

sure differential and the more efficient the rocket engine's operation.

How is the liquid propellant furnished to the rocket engine? Both fuel and oxidizer have to be continuously fed, under pressure, to the thrust chamber. This can be done either by high-pressure propellant tanks, or by a lightweight pumping system operated by a gas turbine. Unfortunately high-pressure tanks are necessarily heavy, and therefore turbopump assemblies are frequently used in modern high-altitude missiles and rocket aircraft, where low weight and large propellant loads are all-important.

Fig. 2c shows a typical turbopump arrangement. A pressurized gas sphere is necessary to start propellant flow to the pumps and to condense slightly the hydrogen peroxide—the gas whose decomposition drives the turbine. The functions of the gas sphere in the turbopump and in the pressurized engines are quite different, and this has been suggested in the diagrams by the thickness of the outlines of the sphere and the tanks it pressurizes.

The operation of a turborocket (turbopump rocket engine) may be described in terms of supply and demand. A slightly compressed monopropellant, such as hydrogen peroxide, is forced into a gas generator, where it rapidly decomposes with the aid of a suitable catalyst. The decomposition products impinge on a turbine which drives two directly coupled pumps. At the same time, oxidizer and fuel are flowing under slight pressure to their respective pumps; from here they are delivered at high pressure to the thrust-chamber injectors. One of the propellants is used to cool the combustion chamber by passing through the chamber jacket on its way to the injector.

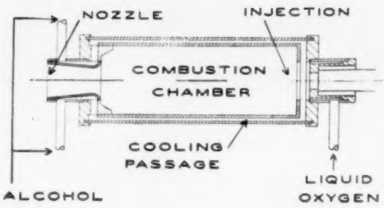


Fig. 3. The principle of the Wyld regeneratively cooled rocket engine.

It is easy to appreciate the difficulties in pumping hundreds of pounds of propellants per second, in injecting, properly mixing, igniting, and burning them in a confined area which must be adequately cooled. The rocket engineer must feel at home with high temperatures, pressures, and exhaust velocities. Every switch, valve, control, seal, and manifold must function properly under all conditions or an expensive engine and missile may fail.

Once the propellants burn together, the temperature rises sharply in the combustion chamber, and the pressure there reaches, for example, 215 pounds per square inch in the German wartime V-2 engine and 300 pounds in the American Viking rocket. Thermal energy is converted into directed kinetic energy as the hot reaction products expand through the nozzle of the chamber. The rocket will continue to gain velocity until propellant exhaustion cuts off the thrust.

Present-day liquid bipropellant rockets fire for up to several minutes before their fuel is exhausted. The V-2 normally fires about 60 seconds, by which time it has reached a velocity of 3,500 miles per hour and an altitude of 20 miles; it coasts upward the remaining 80 or more miles of its climb. The Navy's Reaction Motors-powered, Martin-built Viking fires for as long as 75 seconds, when it may be 30 miles high and traveling at more than 4,000 miles per hour.

In attaining such performance, the effective cooling of the combustion chamber is a vital problem which had haunted experimenters from the very beginning of liquid-propellant work. Materials that could stand extraordinarily high temperatures had to be developed and tested, but this was not enough. Methods were also worked out to lower wall temperatures by allowing small amounts of a cooling liquid to seep into critical parts of the firing area—a process known as film cooling.

In the early days of modern rocketry, someone thought of circulating water in

(Continued on page 58)

The Douglas Skyrocket here takes off with the aid of solid-propellant booster rockets. In other flights, this missile has been air launched from a mother plane, and it has broken a number of world speed and altitude records. Department of Defense photograph.

NEWS NOTES

By Dorrit Hoffleit

AFTER 50 YEARS

The unexpected recovery of the lost asteroid 515 Athalia, unobserved for half a century, has just been announced by Dr. Paul Herget, University of Cincinnati. Athalia was discovered photographically on September 20, 1903, by Max Wolf at Heidelberg. The few observations extended only to October 19th, and although its orbit was computed, this faint minor planet was not picked up again in later years.

Since 1949, Dr. Frank Edmondson at the University of Indiana has been systematically searching for lost minor planets with a 10-inch Cooke camera (*Sky and Telescope*, September, 1954, page 373). In recent months 14 "new" minor planets were observed on at least three occasions each—the minimum number of observations for an orbit calculation. At Cincinnati, using the giant electronic computer at General Electric's jet engine plant, Dr. Herget computed the orbits of the 14 asteroids in just 14 minutes—a job that would have taken a week by laborious hand-computing methods.

Comparison of the newly computed orbits with older lists of asteroids was made by Dr. Peter Musen, who found that one of the 14 was the long-lost Athalia. Few other minor planets that have been lost so long are still to be recovered.

"SATELLITE SCARE" UNFOUNDED

On August 23rd, *Aviation Week* published a brief note in which it stated that two objects circling the earth had been identified as natural, not artificial satellites. They were supposed to have orbits 400 and 600 miles above the earth's surface. Dr. Lincoln LaPaz, of the University of New Mexico, was stated to have headed the identification project. This story has proven unfounded, although it has been widely quoted and amplified in the press.

In a statement to the press, on August 23rd, Dr. LaPaz said in part:

"As regards the *Aviation Week* story on the satellite search, summarized in the Associated Press release shown me, it is false in every particular insofar as reference to me is concerned. I have not been sent back and forth between White Sands Proving Ground and the Mount Palomar Observatory, as the story asserts. In fact, my only communication with anyone at Mount Palomar on the matter of nearby satellites has related to a paper on such satellites that I recently published in the journal of the Astronomical Society of the Pacific."

The technical paper referred to was published in February, 1954; Dr. LaPaz discussed the possibility of testing a point in relativity theory from observations of the advance of perigee of a hypothetical artificial or natural satellite. In a footnote he calls attention to the search for possible natural satellites being carried out for a different purpose by Clyde Tombaugh under U. S. Army sponsorship.

On August 25th, a press release by Col. Walker W. Holler, the commanding officer of the Office of Ordnance Research, Durham, N. C., confirmed the army's sponsorship of the basic research project at White Sands Proving Ground with which Mr. Tombaugh, the discoverer of Pluto, is connected. Part of his activity is in the satellite field. It was further stated that Dr. LaPaz had no connection with the Ordnance Research satellite project. Col. Holler also said:

"As to the success of current efforts to locate an earth satellite of the type described, we are not aware of all the work that may be going on outside of Ordnance auspices. The Ordnance-sponsored work has not as yet located any earth satellites."

RADIO-STAR DISTANCES

A promising method for measuring the distances of radio sources has been developed by D. R. W. Williams and R. D. Davies, of the Jodrell Bank Experimental Station in England. They have applied the method to the strong radio stars known as Cassiopeia A and Cygnus A. Both sources lie in the Milky Way, and over their continuous radio spectra is superimposed the 21-cm. line of interstellar hydrogen.

In each case, the 21-cm. line has two components representing two spiral arms of the galaxy. Comparison of the 21-cm. intensities and the adjacent continuous spectrum of the radio star indicates how much of the radiation of the radio star is absorbed in traversing the spiral arms. From these absorptions, the distance of the radio source can be inferred with the aid of Oort's model of neutral hydrogen distribution in the galaxy.

The Cygnus source is found to be farther than 9,500 parsecs, the distance of the remoter spiral arm in that direction. From optical observations, this source had already been placed by Minkowski at 34 million parsecs, where it appears to be caused by the collision of a pair of galaxies. On the other hand, the Cassiopeia source is either within or nearer than a spiral arm at 500 parsecs; Minkowski had placed it at 300 to 500 parsecs from the sun. The other spiral arm in the direction of Cassiopeia is 2,500 parsecs away.

IN THE CURRENT JOURNALS

THE SUN NAVIGATION OF ANIMALS, by Hans Kalmus, *Scientific American*, October, 1954. "This article will describe certain remarkable experiments of the past two years which show that such diverse creatures as birds, bees, ants and crustaceans do possess a direction-finding mechanism. They can navigate by the sun and, in some cases, even by the moon!"

RADIO ASTRONOMY, by A. C. B. Lovell and others, *Occasional Notes* of the Royal Astronomical Society, No. 16, April, 1954. "Many more of these radio stars have since [1948] been discovered; some have been related to extra-galactic nebulae and one or two to unusual objects in the Milky Way. Even so, the paradox remains and the general relationship between the radio stars and the common stars and, in fact, between the universe as revealed by light waves and that revealed by radio waves, remains to be elucidated."

OBSERVING THE COMETS, by Elizabeth Roemer, *Leaflet* No. 305, Astronomical Society of the Pacific, October, 1954. "Comets do not always behave as they are expected to. Periodic Comets Schwassmann-Wachmann I and Pons-Brooks are known to have had sudden outbursts of brightness while Comet Pajdusakova faded out unexpectedly in December, 1953. In order to get more information about such events, it would be useful to have more frequent observations than the professional astronomers can make, especially when the comets are bright."

NEW SITES FOR HARVARD METEOR CAMERAS

During the past summer, the observing stations of the Harvard photographic meteor program, under the direction of Dr. Fred L. Whipple, were moved to permanent sites with commercial power facilities. They had operated for six years as mobile field stations at Soledad and Dona Ana, New Mexico, as described by Dr. Whipple in *Sky and Telescope* for February, 1949.

One station is now located at Sunspot, N. M., at an altitude of 9,200 feet on the grounds of the Sacramento Peak Observatory of the Air Force Cambridge Research Center. The instruments are mounted on the crest of the ridge not far from the new 16-inch coronagraph buildings. The second station is located at Mayhill, N. M., some 22 miles northeast of Sunspot.

The cameras were scheduled to be back in operation during October. Their new locations, about 70 miles from their original sites, are expected to provide excellent weather conditions for meteor observing with the extremely rapid Baker super-Schmidt meteor cameras.

The Large Magellanic Cloud is at the left in this picture, and the Small Magellanic Cloud is in the lower right. The overexposed star image in the upper right corner is of Achernar, a 1st-magnitude star in the constellation of Eridanus. Just to the right of the Small Cloud, looking like a fuzzy bright star, is the great globular cluster 47 Tucanae. This photograph was taken by T. Houck with the 3-inch Ross-Tessar camera at Harvard's Boyden station on December 26, 1953, exposure three hours on a blue-sensitive plate. The south celestial pole is located about $1\frac{1}{2}$ inches below the center of the lower edge of the picture. Harvard Observatory photograph.

THE CLOUDS OF MAGELLAN

Otto Struve, *Leuschner Observatory, University of California*

EVERY ASTRONOMER who has been south of the equator has noted the extraordinary richness of the southern sky. Not only is the southern Milky Way far more brilliant and full of structure than its northern counterpart, but the two great naked-eye galaxies in the constellations of Dorado and Tucana lend the southern heavens a mysterious interest that is not shared by the northern sky.

Those of us who have never seen the Magellanic Clouds have all too often minimized the importance of these extragalactic neighbors of ours. Astronomy owes much to Harvard Observatory, whose southern stations, from 1890 to 1925 at Arequipa, Peru, and later in South Africa, have photographed the Clouds of Magellan for two generations. Almost all of our early knowledge of them comes from the work of Harvard astronomers: Henrietta S. Leavitt published in 1907 a list of 808 variable stars in the Large Cloud and 969 in the Small Cloud, and by 1912 she had established the period-magnitude relation of Cepheid variables in the clouds; Annie J. Cannon studied the spectra of the brightest stars in the clouds; and Harlow Shapley and his collaborators collected and systematized all pertinent information.

Hence, to survey the results up to about 1950, one may consult Dr. Shapley's numerous technical articles or his popular book, *Galaxies,* and, for the most recent data, *Introduction to Astronomy,* by Cecilia Payne-Gaposchkin.

Unfortunately, Harvard Observatory is no longer able to carry the entire burden of a large program of southern sky research. It is even more regrettable that no other American observatories are ready at the present time to undertake continuing this work. It therefore looks

as though we were definitely "retreating" from the southern sky, leaving the astronomers in Australia, South Africa, and South America to explore its wonders. In the not too distant future, however, there may come into being a large new co-operative observatory in Africa under the joint sponsorship of several European observatories.

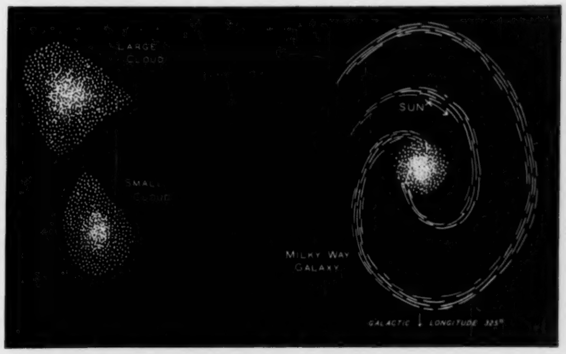
The two clouds are located some 30 and 45 degrees from the Milky Way. Long ago A. S. Eddington pointed out that these large galactic latitudes make it unlikely that the formations are parts of our galaxy, as might have been suggested because they certainly do, as Mrs. Gaposchkin remarks, "look like isolated scraps of the Milky Way; they have even fooled unwary observers from the north into the belief that the sky was clouding up!"

The distances of the two clouds from us are nearly the same, about 50,000 parsecs, as inferred from the apparent magnitudes of the Cepheid and cluster-type variables that they contain (*Sky and Telescope*, July, 1953, page 239). The relative distances of the clouds and their location with respect to the center of our galaxy are shown schematically here. There is no doubt that the clouds are independent galaxies and not merely condensations within the Milky Way.

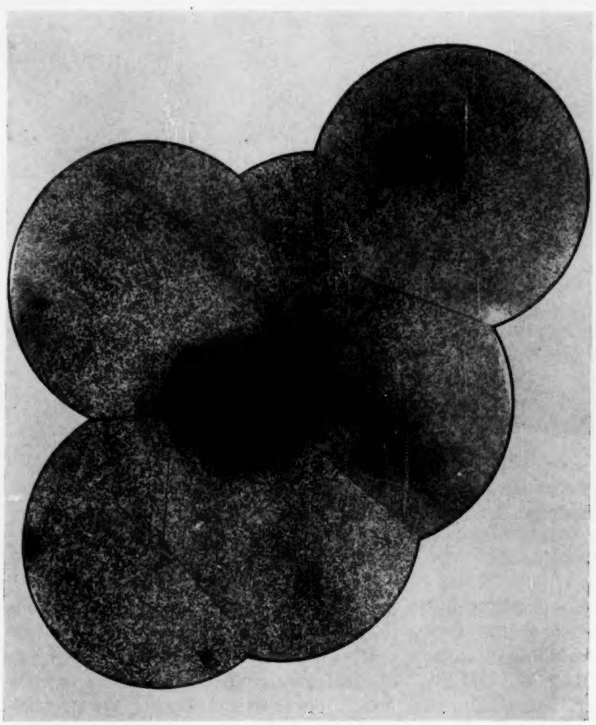
They are, in fact, classified as irregular galaxies, with total absolute magnitudes of −17.5 and −16, rather more luminous than an average small galaxy of absolute magnitude −14. Yet, the clouds are about two and 3½ magnitudes intrinsically fainter than giant spirals like the Andromeda nebula (M31) and our own Milky Way. It is therefore reasonable to expect that the total mass of either cloud will also be considerably smaller than the mass of the Milky Way.

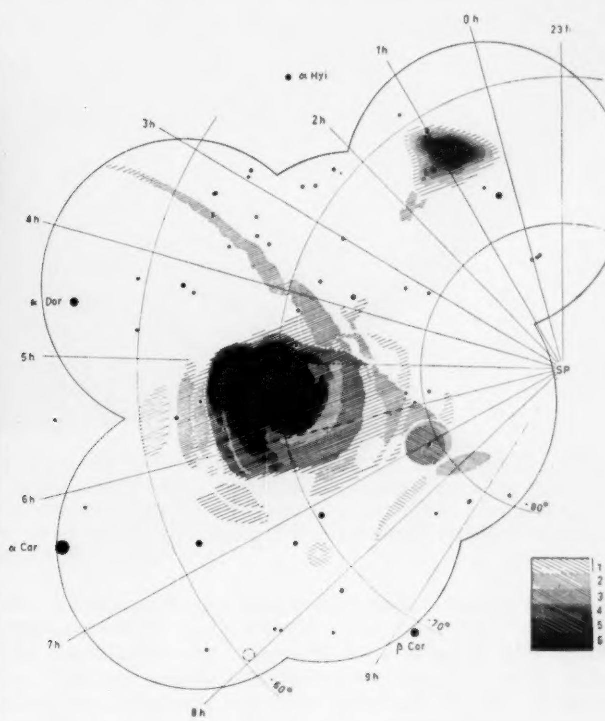
The two clouds are not alike, and neither of them is a miniature replica of the Milky Way galaxy. The Large Cloud contains blue and red supergiant stars, as well as obscuring dust which blots more distant galaxies from view. It has much ionized hydrogen gas in the form of luminous nebulosities—the Tarantula nebula is only one of a great many. There are also several thousand typical Cepheid variables. All these kinds of objects are what we find in the spiral arms of our Milky Way, and are representative of Baade's Population I. There are, however, several globular clusters in the Large Cloud, and at least one of them contains RR Lyrae variables. These are typical Population II objects. Hence the Large Cloud, though made up mostly of Population I objects, has a small admixture of Population II.

The Small Cloud is almost free of obscuring dust; distant galaxies shine through it undimmed. This suggests that the Small Cloud is relatively richer in Population II objects than the Large Cloud. Yet there are some hydrogen emission nebulae in the Small Cloud, so we cannot assign to it a pure type II population. Mrs. Gaposchkin suggests

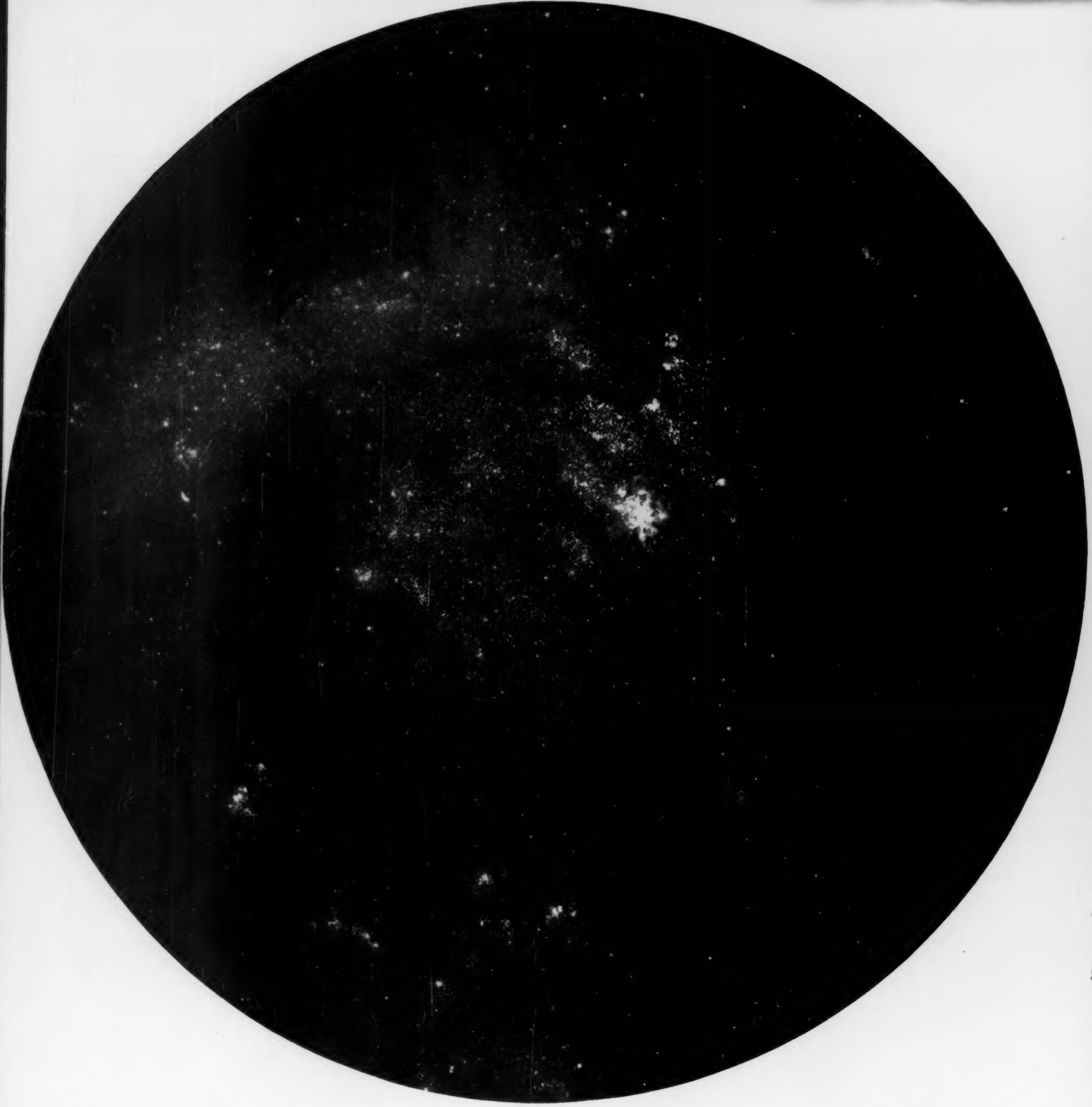


In this schematic diagram, the sizes and relative distances of the Magellanic Clouds and our galaxy are shown to approximate scale.





The outermost regions and extensions of the Large and Small Magellanic Clouds are shown on this mosaic of photographs by G. de Vaucouleurs, who also drew the key map at the right. The relative intensities are qualitative and may not represent actual surface brightnesses. Further details are given on pages 55 and 56.



This photograph of the Large Magellanic Cloud was taken December 10, 1950, by Bart J. Bok, with the ADH Baker-Schmidt telescope at Harvard's southern station. The exposure was 90 minutes on a blue-sensitive plate. Nearly all of the field is shown, with south at the top. To the right of center is the great Tarantula nebula, 30 Doradus; if brought as near to us as the Orion nebula is, this huge glowing mass of hydrogen would be as bright as the full moon and would extend across one fourth of the sky.

that the two populations are about equally represented.

But in 1953, from color measurements of stars, C. S. B. Gascoigne and G. E. Kron had concluded that Population II may actually predominate in the Small Cloud. Nevertheless, unpublished color measurements by Gascoigne indicate the presence of many stars that cannot be clearly assigned to either population, but may be intermediate between the two. This is really not too surprising, because we find more and more that in the Milky Way the sharp division into Populations I and II is mainly a useful simplification of an otherwise rather confused state of affairs.

Not only are the Magellanic Clouds an important source of information about the stellar contents of galaxies, but recently they have added to our knowledge of how two neighbor galaxies may interact. These results concern the structural features of the clouds, some of which show clearly in the illustrations accompanying this article.

In the Large Cloud, there is a pro-

This picture of the Small Magellanic Cloud was taken November 7-8, 1953, by Henry J. Smith, with the ADH telescope. The exposure was one hour on a blue-sensitive plate. Nearly all of the field is shown, with south at the top. The globular cluster 47 Tucanae, much nearer to us than the Small Cloud, is in the lower left. The Magellanic Clouds are so named because they were described in 1521 by a passenger, Antonio Pigafetta, on Magellan's voyage around the globe. In the 17th century, seamen called them the "Cape Clouds."

nounced "axis," which suggested to the Australian astronomer H. C. Russell, in 1890, a resemblance to barred spirals; he noted the cloud's "incipient spiral structure."

Although the Small Cloud is relatively structureless, there is an extension or "wing" in the direction of the Large Cloud, which is almost certainly a tidal protuberance produced by the gravitational attraction of the latter.

The mosaic of photographs shown on page 53 was made by G. de Vaucouleurs at Mt. Stromlo Observatory, near Canberra, Australia, from duplicate exposures made with twin Aero-Ektar f/2.5 cameras of 7-inch focus, usually stopped down to f/4. While the inner parts of both clouds are burned out, their outer structure is well shown. The drawing represents these features schematically. The long faint streamer between 3^h and 4^h right ascension and from $-55°$ to $-70°$ declination points away from the Milky Way. De Vaucouleurs describes it as a "counter-tidal" filament. Another streamer, ending in a diffuse spot at 7^h

and $-80°$, points toward the Milky Way and may be the beginning of a "tidal" filament. The circular spot may be a hydrogen-emission nebula in our galaxy and unrelated to the cloud, but the filament itself is undoubtedly a part of the Large Cloud. As far as I know these filaments have not been photographed by other observers. It would be important to confirm their existence with a powerful Schmidt telescope.

Earlier, de Vaucouleurs had suggested that the Milky Way may possess a tidal extension in the direction of the Large Cloud; now he proposes that there may also be an anti-tidal filament belonging to the Milky Way, pointing away from the Large Cloud, and extending from about $0°$ to $+60°$ in declination along right ascension $17^h\ 30^m$. These results seem to me rather uncertain, and de Vaucouleurs himself points out that they require confirmation. But even without them there is some indication that both Magellanic Clouds show tidal disturbances which are not unlike those remarkable filaments that F. Zwicky has found in several pairs of galaxies.

F. Zwicky used the 200-inch reflector, exposure 30 minutes on a blue plate, to record this pair of galaxies and their tidal and countertidal filaments. The 1950 position of the group is $23^h\ 39^m.4$, $-3°\ 56'$. Mount Wilson and Palomar Observatories photograph.

As de Vaucouleurs has shown, the gravitational attraction exerted by the Milky Way on either cloud exceeds the attraction of one cloud on the other by a factor of about 10. But tide-raising forces depend on the inverse cube of the distance, instead of the inverse square as for gravitational attraction. De Vaucouleurs finds that the Large Cloud exerts a slightly greater tidal force on the Small Cloud than does the Milky Way. By contrast, the tidal force on the Large Cloud exerted by the Milky Way is stronger than that exerted by the Small Cloud.

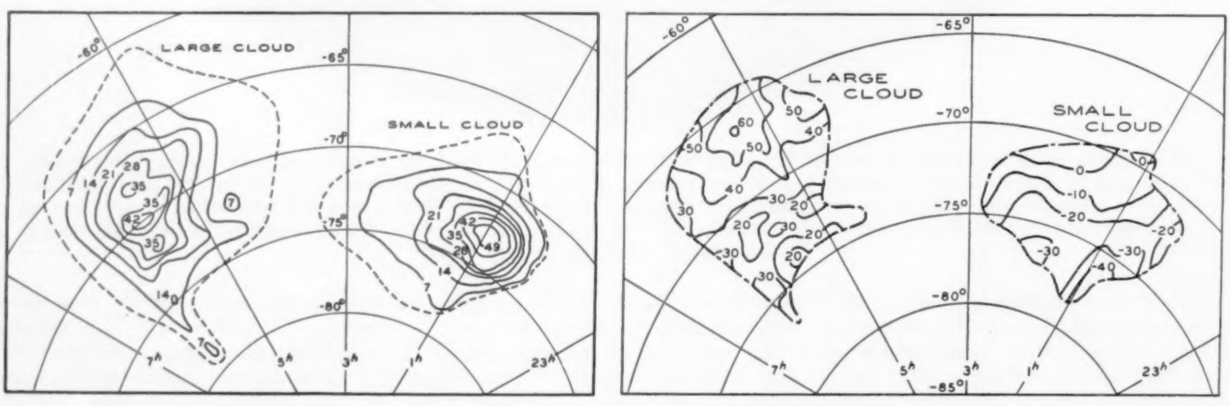
Another very fruitful observational attack upon the Magellanic Clouds is the work in Australia described by Bart J. Bok in his article on radio studies of interstellar hydrogen in the October issue of *Sky and Telescope*. At the Radiophysics Laboratory of the Commonwealth Scientific and Industrial Research Organization in Sydney, F. J. Kerr, J. V. Hindman, and B. J. Robinson have recorded the 21-cm. emission line of neutral hydrogen. They used a 36-foot dish-shaped antenna which gives a resolving power of about one degree in the sky, with a band-width of about eight kilometers per second.

For both clouds they have mapped the distribution of neutral hydrogen and, by means of the Doppler effect, have determined the line-of-sight motions of this hydrogen. Their charts show that the hydrogen gas occupies much larger volumes than those indicated by the stars, and the outer boundaries of the clouds almost touch. The tidal extension of the Small Cloud is especially prominent, and the radio observations seem to confirm the existence of a filament from the Large Cloud toward the Milky Way. There is also a weak suggestion of a bulge toward $3^h\ 45^m$, $-67°$, which may be a part of de Vaucouleurs' countertidal filament. But the resemblance of the optical filament and the radio isophote is, of course, quite hypothetical; perhaps we are here concerned more with tidal distortions of each cloud upon the other.

Kerr, Hindman, and Robinson have computed from their observations the total amount of interstellar hydrogen in the Large and Small Magellanic Clouds as 6×10^8 and 4×10^8 solar masses, respectively. Since the Large Cloud contains much dust, while the smaller has but little of it, the ratio of gas to dust is quite different in the two clouds.

Another problem, of far-reaching importance, is determining the total mass of each of the Magellanic Clouds. The variety of methods that can be applied to these two nearby systems offers much more information than other more distant irregular galaxies can provide.

The total mass of the Large Cloud has been estimated by E. Holmberg from the dispersion in the velocities of the ionized hydrogen nebulae observed long ago by R. E. Wilson. The result is 2×10^9 solar masses. The Small Cloud has only one measured radial velocity of a gaseous nebula. Hence, Holmberg estimated its mass as 6×10^8 suns from an assumed ratio of mass to total luminosity. This result is uncertain, but it seems reasonable to accept a ratio of about 3 in the two total masses. Since the amounts of hydrogen are nearly the same in the two clouds, it would follow



These charts are from 21-cm. observations by Australian radio astronomers. Left: The curves are contours of equal hydrogen brightness; dashed lines are limits of detectable 21-cm. radiation. Right: The numbers show line-of-sight velocities of the emitting hydrogen in kilometers per second, plus for recession (the unlabeled figures in the Large Cloud) and minus for approach, after allowance has been made for the motion of the observer.

that the ratio of gas to stars is unexpectedly large for the Small Cloud.

The Australian radio observers have determined the radial velocities of a large number of small areas distributed over the two clouds. Their second diagram shows that, with respect to the center of the Milky Way, the Large Cloud recedes with an average speed of 37 kilometers per second, while the Small Cloud approaches at the rate of 16 kilometers per second.

It would be tempting to regard the difference of 53 kilometers per second as orbital motion of a double galaxy. This interpretation is erroneous, for de Vaucouleurs has shown the predominance of the gravitational field of the galaxy. The two clouds move around the Milky Way as two planets (or comets) move around the sun. Moreover, were we to make the wrong assumption and disregard the attraction of the Milky Way, we would find for the clouds a total mass of 10^{10} suns; this is inconsistent with the masses of 1.5×10^9 and 1.0×10^9 suns tentatively derived by de Vaucouleurs from the axial rotations of the two clouds, as revealed by the radio observations. His mass of the Large Cloud agrees well with that found by Holmberg, but there is a fairly serious discrepancy for the Small Cloud.

There is yet another way by which the masses of the Magellanic Clouds could be estimated. As noted earlier, the clouds are about two and $3\frac{1}{2}$ magnitudes fainter, on the absolute scale, than the Milky Way. If the latter contains 10^{11} suns, we compute from the ratio of total luminosities that the masses of the Large and Small Clouds are about 10^{10} and 5×10^9 suns, respectively. These rather crude estimates presuppose that each cloud resembles the Milky Way both in stellar population and in distribution of gas and dust.

Thus we are faced with a marked disagreement between the mass of 10^{10} suns, just found for the Large Cloud, and the values near 1.5×10^9 resulting from the work of de Vaucouleurs and of Holmberg. How is this to be explained?

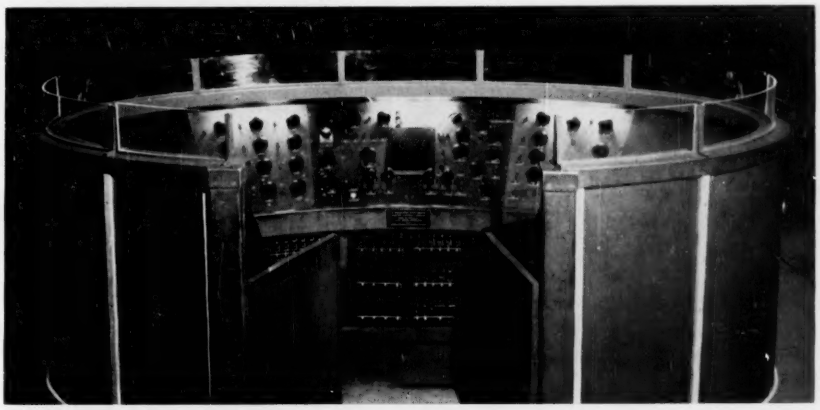
If we assume that the Large Cloud contains relatively more stars of large mass than the Milky Way, then the integrated luminosity would not be a direct measure of the number of stars of solar mass; according to the mass-luminosity relation every star of mass 10 adds as much light as 5,000 suns. Hence, the cloud would appear relatively more luminous than a sample of the Milky Way containing the same number of stars of solar mass. This is precisely what we have already found: The Large Cloud contains a greater proportion of Population I stars than does the Milky Way.

Thus it seems safe to say that the estimates of de Vaucouleurs and Holmberg are nearly correct. If the integrated luminosities of the Large Cloud and the Milky Way were accurately known, we might even estimate numerically the ratios of the two populations in the Milky Way and in that cloud. Even though such a computation would be premature at the present time, the qualitative result is important when we consider the origin and evolution of large and small galaxies.

A New Console for the Hayden Planetarium

A LARGE planetarium projector is necessarily a complicated instrument, and at New York's Hayden Planetarium it was found that the complications became acute as the number of special effects—both sound and optical—increased. To put the bewildering variety of controls within easy reach of the demonstrator, a new console was built by the Altec Service Corporation.

One panel of the control board is for permanently installed special effects, such as aurorae, comets, meteors, and novae, and a second panel is for special effects designed for a particular demonstration. The third controls motions of the stars, sun, moon, and planets, and the fourth handles celestial navigation and sky illumination effects. In addition, four standby panels allow for further development, as effects for future demonstrations are conceived.



The Hayden Planetarium's new console, first used on September 26th. Elliptical in shape, it is nine feet wide, five feet deep, and three feet high. After five months spent in its design, seven months were required for construction. The installation took six days. American Museum-Hayden Planetarium photograph.

VULNERABILITY OF ARTIFICIAL SATELLITES

In *Jet Propulsion,* the journal of the American Rocket Society, Dr. L. H. Thomas, of Columbia University, cautions against the current belief that a space station circling the earth would be practically immune to earth-based attack.

True, a direct hit by a rocket would require exceedingly accurate aiming. This, however, would not be necessary. The space station would be vulnerable to small particles traveling in the same orbit but in the direction opposite to that of the satellite. To put an attacking rocket into the proper orbit would not be difficult. Equipped with a warhead timed to burst about half a circumference away from the satellite, the rocket would release a cloud of pellets, each of which would be capable of penetrating 1/10 of an inch of steel when striking the satellite at a relative speed of twice the orbital velocity of the station itself.

As the cloud of pellets would gradually disperse around the orbit, the satellite would pass through this artificial meteor swarm again and again, and finally continuously.

While the cost of establishing a space station might run into several billion dollars, Dr. Thomas concludes that it could be destroyed for less than a million.

ASTRONOMERS WANTED

At the U. S. Naval Observatory and in other Federal agencies there are vacant positions for astronomers, paying from $3,410 to $8,360 per year. Applicants must have had appropriate education or experience, but no written Civil Service test is required. Application forms and further information may be obtained from the U. S. Civil Service Commission, Washington 25, D. C., or from larger post offices.

ASTRONOMICAL SCRAPBOOK

The Faintest Stars Visible

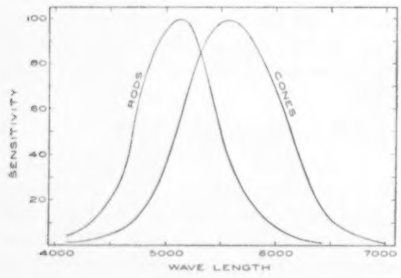
EIGHTH-MAGNITUDE stars are not usually regarded as naked-eye objects, but with suitable precautions they can be seen. This was demonstrated half a century ago at Lick Observatory in a classic experiment by Heber D. Curtis, later the director of the University of Michigan Observatory (Lick Observatory *Bulletin* 38, 1901).

Much of the trick is in shielding off the light of the sky and in letting the eye know in exactly what direction to look. Curtis did this by fixing two blackened screens to the tube of the 12-inch Lick refractor, 15 feet apart. The screen at the eye end was pierced with a ½-inch hole, the other by a ¼-inch hole, and the screens were aligned so that a star seen through them would be on the crosswires of the finder.

To test whether a particular star could be seen, Curtis clamped the telescope at the proper declination, and then slowly moved the instrument, with his eye at the ½-inch hole. When he believed that the star could be seen through the holes, its position could be checked in the finder. The trial was called a success only if the star was within one or two minutes of arc of the intersection of the crosswires. From tests on three nights, Curtis found stars of magnitude 7.2 and 7.4 easy, 8.1 seen, 8.3 seen with difficulty, and 8.5 glimpsed very doubtfully.

This experiment should be fairly simple for anyone with access to a professionally mounted equatorial telescope in good adjustment. One can hardly hope for quite so striking results without a sky as pure and dark as that at Lick around the turn of the century.

A closely allied problem is the faintest star visible in a telescope of given size. This was discussed in the August, 1953, *Sky and Telescope* by F. J. Kelly and by Dr. J. G. Baker. But there are some other aspects of the problem worth examining.



As the eye becomes dark adapted, the wave length of the light to which it is most sensitive decreases from about 5600 to about 5100 angstroms, corresponding to the change from cone to rod vision.

There are cases of experienced observers who are able to see in small telescopes stars some two magnitudes fainter than the average observer can. About 20 years ago, Dr. Luigi Jacchia, with the 6-inch refractor of the Bologna Observatory, habitually observed stars down to magnitude 14.3, and 14.6 on about half of the clear nights. The faintest star he saw was 15.4; he has also seen Pluto with this instrument. Although the observatory is in the heart of a large city, Bologna is famous for the inadequacy of its street lighting.

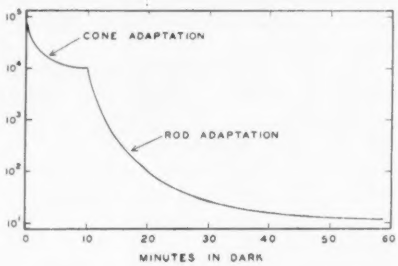
Mr. Kelly has pointed out some similar results by the veteran Italian variable star observer, R. B. Lacchini. His extensive experience with five refractors of different apertures gave as the faintest magnitudes reached under average conditions: 2.4-inch, 12.5; 2.8-inch, 13.3; 3.9-inch, 14.5; 5.3-inch, 14.8; and 5.9-inch, 15.0. Here again is performance about two magnitudes better than the limits usually cited.

Unusual vision and transparent skies are undoubtedly part of the explanation, but several other factors can be mentioned. Chief among these is proper dark adaptation of the eye.

The eye has two types of mechanism for detecting light, cones and rods. Under daylight illumination light is perceived by the cones, which are most numerous in the central parts of the retina; night vision uses the rods, found mainly in the outer zone of the retina. The rods contain a light-sensitive pigment known as visual purple (which is actually red) that bleaches when exposed to light. Strong illumination entirely bleaches the visual purple, so that rod vision does not operate by day, but in the dark the purple gradually changes back to its unbleached form. This is why the sensitivity of the eye increases during rest in the dark. At the same time the pupil of the eye enlarges, but the gain from this is much less important than from the growing sensitivity of the retina.

Five minutes after going outdoors at night from a lighted room, an observer's eyes have become accustomed enough to the dark so that he might think they were already dark adapted. But the process has only begun! Laboratory experiments show that even after 10 hours in the dark the sensitivity of the eye is still increasing, at an ever-slackening rate. The diagram in column 3 suggests as a practical rule that observers should remain in the dark for at least 30 minutes before attempting any extremely faint objects.

You can turn to advantage the fact that the rods are relatively insensitive to red light. This means that a dim red light can be used occasionally for taking notes or consulting charts without destroying dark adaptation. Furthermore, wearing deep red goggles allows one to maintain adaptation even in a lighted room.



As the eye rests in the dark, its increase in sensitivity is first due to cone adaptation, but later, gain from rod adaptation is much greater. The vertical co-ordinate is least detectable light intensity, on an arbitrary scale.

Both Jacchia and Lacchini state that their ability to recognize extremely faint stars came after considerable observing experience. Evidently the eye can be gradually trained to reach dimmer and dimmer magnitudes, somewhat the same way it can be trained to recognize delicate planetary detail. The two skills are probably distinct, for they are not always found in the same individual, but in both the education of the eye seems to be largely subconscious. J. A.

PRINCIPLES OF THE ROCKET ENGINE

(Continued from page 50)

a cooling jacket around the combustion chamber. This was fine for a test-stand engine, but missiles could not carry the weight of the water in addition to propellants. Hence one of the propellants—either the fuel or the oxidizer—has to do the task. Such a rocket engine is referred to as regeneratively cooled.

To make the idea practicable, the coolant must have high heat capacity, and the wall material must transmit heat readily from the combustion chamber. America's first regeneratively cooled rocket engine was successfully tested in 1938. Fig. 3 is a schematic drawing of this early engine. It was designed and built by the late James Wyld, one of the founders of Reaction Motors, Inc., who then was working with the American Rocket Society.

In an article next month we shall discuss some modern rockets, and how these principles have been applied in their development.

THE LUMINOUS SHOCK TUBE

A Tool for Experimental Astrophysics

LAWRENCE H. ALLER, *University of Michigan Observatory*

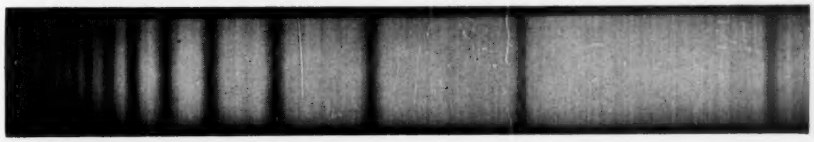


Fig. 1. In the atmosphere of a star of spectral class A, conditions of temperature and pressure favor heavy absorption of the outgoing starlight by hydrogen atoms. These produce the Balmer series of dark lines that dominate the visible portion of the spectrum of such a star, shown here. At the red end (right) the lines are far apart, but at shorter wave lengths they crowd closer and closer.

IT IS SURPRISING how much information about a star can be found from the shapes of its spectrum lines. The breadth and blackness of an absorption line are affected by many properties of the star, such as the temperature, pressure, turbulence, and atomic composition of its atmosphere, and by stellar rotation. Each of these influences the shape of the line in characteristic fashion, so that their effects can be disentangled, at least in principle. Clearly, the interpretation of stellar spectra depends greatly upon what we think we know about physical processes such as the causes of line broadening.

To the astrophysicist, the Balmer lines of hydrogen are particularly important, as they appear in stars from the coolest *M*-type ones (with surface temperatures of about 2,000° K.) to the hottest *O* stars (about 50,000° K.). The hydrogen lines attain their greatest intensities near spectral class *A0* (Fig. 1), and they have frequently been used to estimate the densities and temperatures of stellar atmospheres.

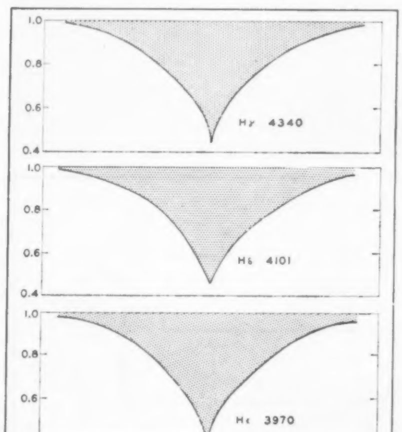


Fig. 2. Profiles of absorption lines of hydrogen in the spectrum of Iota Herculis. The center of each line is only about 0.4 as bright as the continuous background on either side of the line. Note the sharp cores and broad wings of the hydrogen lines in this star of spectral type B. These profiles were measured on plates taken at Mount Wilson Observatory.

In spectral classes *F*, *B*, and especially *A*, the Balmer lines display prominent *wings* many angstroms wide (Fig. 2). These broad wings are caused by the perturbations produced by ions passing near the radiating atom. That is, a hydrogen atom starts to emit a quantum of energy, but finds the position of its energy levels changed by the electrostatic field of a passing ion. Hence, the wave length of the emitted radiation will be increased or decreased a little from its normal value. Consequently, the line produced by many such atoms will be broadened; absorption lines will be similarly broadened if the atoms are disturbed in the act of absorbing.

We speak of this line broadening as an *interatomic Stark effect*. It differs from the Stark effect produced in the laboratory by large-scale, uniform electric fields. In the star, the radiating and absorbing atoms are jostled by the action of the electric fields produced by the randomly moving charged particles.

The theory for calculating the line broadening of hydrogen has been based on the following approach. It is known from laboratory work that any given line is split into a number of individual components whose spacing depends on the strength of the electric field. If electric fields are not produced by charged condenser plates as in a laboratory experiment, but by ions in the discharge tube or stellar atmosphere, then each component will be smeared out, because the charged particles are distributed more or less at random around the radiating atom, and the electric fields they cover will vary over a large range. The shape of the spectral line will depend on the disturbances produced by the charged particles. The individual components will no longer be seen, as they become all smeared together.

Astronomers have calculated the broadening of the hydrogen lines with the aid of the Holtsmark theory, in which we may think of the electric field acting upon the atom at any one time as being simply that produced by a random distribution of charged ions. The motions of the ions during the time the disturbed atoms radiate are neglected.

Support for the Holtsmark theory

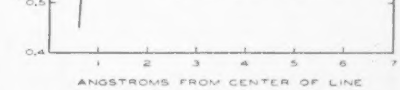


Fig. 3. The solid curve shows one side of the observed profile of the sun's hydrogen-alpha line. The vertical scale is intensity, in terms of the neighboring continuous spectrum; the horizontal scale is difference in wave length from that of the center of the line. The broken curve is the prediction by Holtsmark's theory, which does not fit the observed profile.

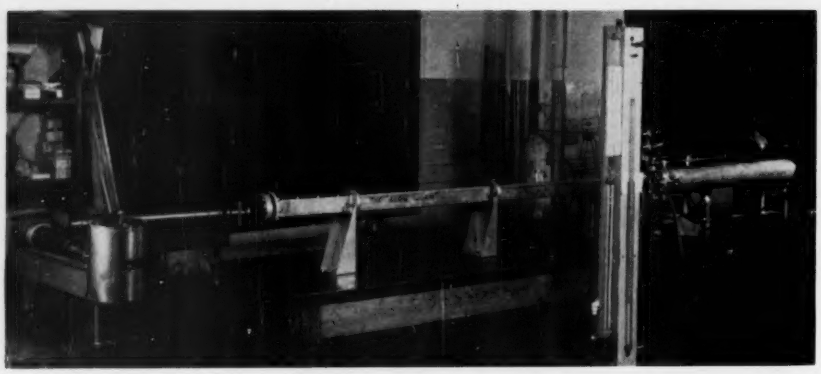


Fig. 4. In this first arrangement of the University of Michigan shock tube, the breakable membrane separating the high-pressure tube (extreme right) from the expansion chamber was located behind the vertical manometer or pressure gauge. The spectrograph is mounted at the left, to photograph the spectrum through a glass window. The pictures of Figs. 6 and 7 were made with this setup, which was later changed to procure the time-resolved spectrum of Fig. 8. Photographs by E. B. Turner.

seemed at first to be provided by the early experiments carried out in the laboratory of W. Lochte-Holtgreven in Kiel, Germany, with a whirling-water arc. In this device, a stream of water whirls in a tube down whose axis an electric arc is struck. The water molecules near the center of the tube dissociate into atoms of hydrogen and oxygen, and these are excited and ionized by the energy of the arc. The Balmer lines of hydrogen and certain oxygen lines appear in great strength. The shapes and intensities of the Balmer lines could be interpreted in terms of the Holtsmark theory at a unique temperature and density. Later experiments, however, indicated that at certain temperatures and densities of astrophysical interest the Holtsmark theory appeared to need correction.

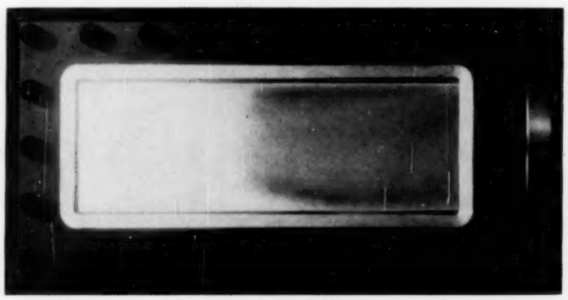
Meanwhile, this same theory did not seem to account for certain details of the hydrogen line shapes in the hotter stars, and its failure to describe the Balmer lines in the sun was far outside the liberal limits allowed by "astrophysical accuracy." Fig. 3 compares the observed profile of the hydrogen-alpha line in the integrated light of the sun with that predicted by Lowell Doherty on the basis of Holtsmark theory and a model solar atmosphere calculated by A. K. Pierce and the writer.

The discordances in the case of the sun were so great that C. de Jager postulated the existence of tiny regions on the solar surface many hundreds of degrees hotter than the average, while nearby regions were much cooler. No mechanism capable of maintaining such huge temperature differences over short distances on the solar surface has been suggested.

Fortunately, another experimental approach is possible. The luminous shock tube (described, for example, by Arthur Kantrowitz, of Cornell University, in the September, 1954, *Scientific American)* turns out to have important possibilities for astrophysical research. Two of our physics students at the University of Michigan, Eugene B. Turner and Alan Kolb, have been applying the shock tube to the study of line broadening in hydrogen and also in argon. Mr. Turner has supplied most of the illustrative material with this article.

The experimental apparatus, pictured in Fig. 4 and diagrammed in Fig. 5, is relatively simple. A long tube is divided into two chambers by a thin membrane. One chamber contains a gas, usually hydrogen, at a high pressure; in the photograph this chamber is the strongly reinforced pipe at the extreme right. The other contains a heavier gas, usually argon or neon, at a much lower pressure; in

Fig. 6. As seen through the viewing window at the end of the expansion chamber, just after the shock wave is reflected from the tube end the temperature rises sharply and the gas momentarily glows brilliantly.



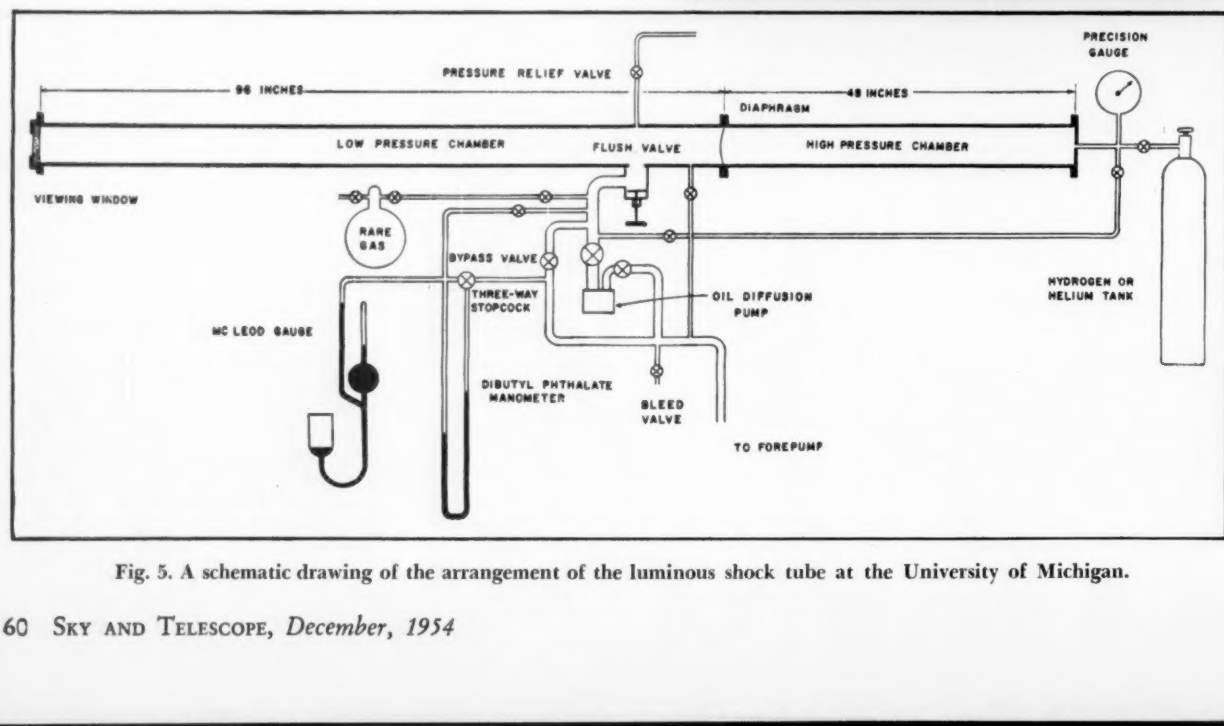


Fig. 5. A schematic drawing of the arrangement of the luminous shock tube at the University of Michigan.

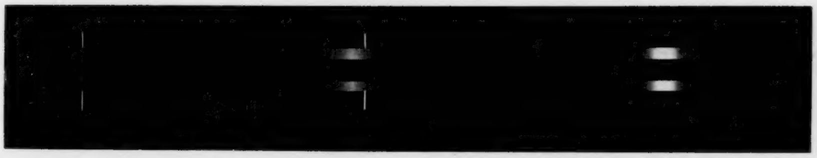


Fig. 7. Two spectra of hydrogen brought to incandescence in the shock tube. The hydrogen lines, of which H-beta is to the right and H-gamma is in the middle, appear greatly broadened. Neon lines, on the other hand, display relatively little broadening.

the picture, this chamber is the long, rectangular pipe in the center. If the broadening of hydrogen lines is to be studied, a small amount of hydrogen is added to the noble gas in the low-pressure chamber. The oil diffusion pump evacuates the chamber to less than 10^{-3} millimeter of mercury pressure before the noble gas is introduced to a pressure of a few millimeters. The high-pressure chamber is filled to a pressure of 10 to 100 atmospheres.

When the thin membrane is broken, the expanding gas rushes down the tube, compressing the initially present gas like a piston. A shock wave with a faintly luminous front is set up. When this shock wave strikes the wall, it is reflected and the zone behind the reflected wave lights up brilliantly (Fig. 6). The luminous region emits the Balmer lines, lines of the noble gas, and a continuum whose relative intensities depend on the original pressure difference and strength of the shock (Fig. 7).

An important feature of the shock wave work is that the pressures and temperatures at each point and time can be calculated by well-established hydrodynamical equations. Allowance can be made for the energy loss effects of excitation and ionization. A stellar atmosphere is simulated under controlled conditions.

To see how the true hydrogen line profiles change with time, Turner focused a narrow portion of the luminous zone on the spectrograph slit and then photographed the spectrum on a film wound on the inside of a rapidly rotating drum. These spectra show generally that the initially narrow hydrogen lines broaden as the density of ions is built up and then slowly fade as recombination occurs. In Fig. 8, each spectrum line is at first narrow, in the region of the reflected shock wave. Then after the shock wave has been reflected again, the several shock waves interact, and the temperature rises still higher, so that the spectrum line broadens considerably. Finally, as the hydrogen ions recombine, the line fades and becomes narrower.

Measures of the shapes of the hydrogen lines originating in the shock tube do not produce confidence in the Holtsmark theory. Kolb has developed a theory that accounts for at least part of the observed line shape. Among the more serious faults of the Holtsmark theory is its neglect of the motions of the disturbing ions on the radiating atoms. However, all theories fail in the extreme wings or very near the line center.

With the aid of the shock tube, measurements of the shapes and absolute strengths of the lines of other elements become possible. This new technique promises to be a tool of very great astrophysical importance.

The shock tube work on line broadening is the experimental supplement to our observational and theoretical program on the composition of the atmospheres of the hot stars. This abundance program is being carried out at the University of Michigan on a grant from the National Science Foundation. Progress in this research will depend on the accurate determination, by careful experimental methods, of the dependence of line broadening on temperature and pressure.

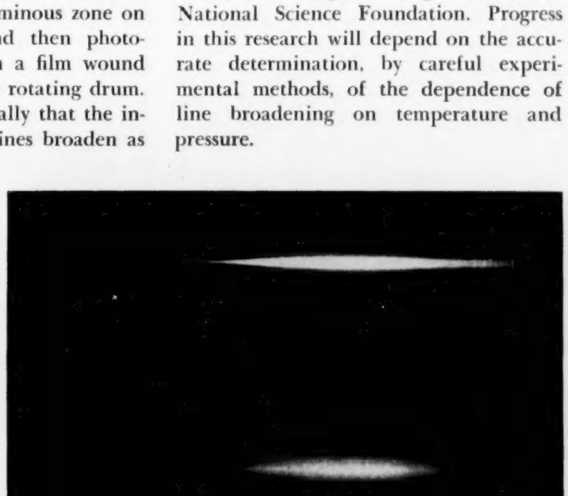


Fig. 8. How line width changes with time for the H-beta line (top) and also for H-gamma. Time here progresses toward the right.

FIFTY YEARS AT MOUNT WILSON

(Continued from page 47)

cooperation in astrophysical research through the invitation to Mount Wilson, from time to time, of investigators specially qualified to take advantage of the opportunities afforded by the Solar Observatory.

This program was soon implemented by instruments of unmatched power. For solar observations a 60-foot tower telescope was erected in 1907, and a 150-foot in 1911. The 60-inch reflector was completed in 1908, and the 100-inch Hooker reflector, for nearly three decades the largest telescope in the world, was in operation by 1919.

It is hardly possible even to summarize the wealth of astronomical research that has flowed from Mount Wilson. Among many developments that have had far-reaching influence on modern astronomy are Hale's and the Babcocks' investigations of solar magnetic fields, Adams' and Kohlschuetter's determinations of the distances of stars from their spectra, Shapley's studies of star clusters, Seares' establishment of the international system of stellar magnitudes, and Hubble's and Baade's searching investigations of galaxies. All these and other Mount Wilson studies are part of the foundations of today's astronomy.

It was the over-all success of the Mount Wilson program that encouraged astronomers to consider building a 200-inch telescope and to locate it on another California mountaintop. The Mount Wilson and Palomar Observatories now function under a single administration.

In the last century, Simon Newcomb called Poulkovo Observatory the astronomical capital of the world. No one can question that Mount Wilson has held this title during the present century, an honor that now belongs to the Mount Wilson and Palomar Observatories.

HOLCOMB OBSERVATORY AND PLANETARIUM DEDICATION

At Butler University in Indianapolis, the James Irving Holcomb Observatory and Planetarium was formally opened on November 5th, with ceremonies in which the governor of Indiana and Charles F. Kettering, of General Motors Corporation, took part.

As described on the News Notes page, January, 1954, the observatory houses a Fecker 38-inch Cassegrainian reflector and a Spitz planetarium. The total cost of the 98- by 26-foot limestone building and its equipment was $325,000.

Dr. Harry E. Crull, head of Butler's department of mathematics and astronomy, is director of the new institution.

Amateur Astronomers

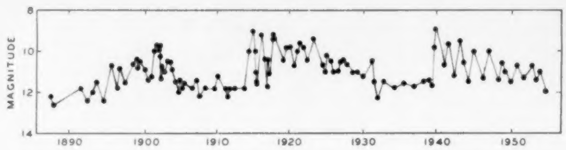
Variable Star Observers Meet in Rhode Island

LADD OBSERVATORY of Brown University was host to the American Association of Variable Star Observers during its 43rd annual fall meeting at Providence, R. I., on October 8-9. Some 60 members and guests attended.

Considerable activity by both the variable star and solar observers of the association was reported. Over 52,000 estimates of variable stars were collected during the past 12 months, and at least two amateur members now have photoelectric photometers.

The session for scientific papers was held at the Seagrave Observatory of the Providence Skyscrapers, at North Scituate, R. I.

Mrs. Margaret W. Mayall, AAVSO recorder, described the light variations of the peculiar novalike variable Z Andromedae. Since its discovery in 1887, this star has three times risen from magnitude 12 to 9, and then faded slowly with ever-lessening fluctuations in brightness, as shown by the accompanying light curve. When Z Andromedae is bright, its spectrum resembles that of a nova; at minimum brightness it appears to be that of an *M*-type star with weak emission lines. This composite spectrum has suggested that the variable is a close double, with blue and red components. Mrs. Mayall pointed out that at present the star is quiescent, at nearly its minimum light, so that persistent watch may catch a fourth outburst within the next few years.



Nearly seven decades of the light variations of the star Z Andromedae, plotted by Margaret W. Mayall.

An important paper was by Leith Holloway, of Philadelphia, in which he applied the powerful statistical technique of autocorrelation analysis to the interpretation of light curves of long-period variables. H. Bondy, of New York City, explained the construction of a simple amateur telescope (akin to the Lyot coronagraph) for observations of prominences on the sun.

From Harvard Observatory, Mrs. Virginia McK. Nail and Dr. Dorrit Hoffleit told of photographic studies of variables in the Large Magellanic Cloud and in the central parts of the galaxy; and Mrs. J. Dishong reported the recognition on Harvard plates of a "new" nova in Sagittarius that reached magnitude 9 in 1928.

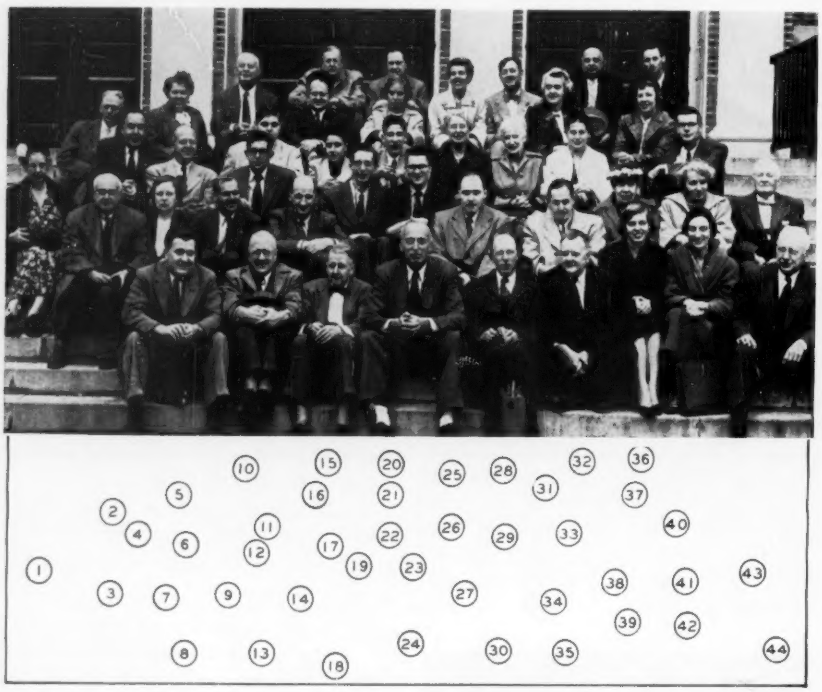
Others of the 14 papers covered subjects as diverse as the complex light variations of DF Cygni and the telescopic visibility of stars in the daytime.

The social program centered around the society dinner, which was featured by Dr. Harlow Shapley's summary of the astronomical highlights of the past year, presented in his absence by Miss Hoffleit. Dr. Charles H. Smiley, director of Ladd Observatory, told of his eclipse expedition to Pakistan to photograph the zodiacal light during totality on June 30th, illustrating his account with Kodachrome slides. Clouds prevented post-dinner observations with the Skyscrapers' 8½-inch Clark refractor.

Officers of the AAVSO for the coming year are: president, C. Fernald; vice-presidents, Miss M. Harwood and R. Hamilton; secretary, C. Ford; treasurer, P. Witherell; and recorder, Mrs. Mayall.

The highlights drawn up by Dr. Shapley are: the radio map of the summer sky by Ohio State radio astronomers; the reopening of the Poulkovo Observatory in Russia; completion of two great sky surveys, one with the 20-inch refractor at Lick Observatory, the other by W. J. Luyten of his 25-year search on Harvard plates for stars with large proper motions; discovery of flare-type stars in the Orion nebula, at the Tonanzintla Observatory; and M. Humason's list of the radial velocities of 580 galaxies, secured at Mount Wilson and Palomar Observatories.

Further highlights include: the practical utilization of solar energy, by the solar cooker developed in India, by Convair's solar furnace, and by solar batteries; the color-magnitude array for stars in globular cluster M3, by A. Sandage



The American Association of Variable Star Observers at Providence, R. I., October 9, 1954. Photograph by C. H. Smiley.

KEY TO PHOTOGRAPH

1, Mrs. Reeves; 2, W. P. Reeves; 3, C. W. Brown; 4, F. W. Hoffman; 5, Mrs. M. Mayall; 6, E. C. Hornby; 7, Mrs. Brown; 8, C. Ford; 9, A. Marshall; 10, D. W. Rosebrugh.

11, E. DeGennaro; 12, K. Weitzenhoffer; 13, C. Fernald; 14, F. H. Reynolds; 15, R. Buckstaff; 16, H. Bondy; 17, E. Lizotte; 18, R. Seely; 19, E. Oravec; 20, Mrs. Buckstaff.

21, Mrs. Fernald; 22, unidentified; 23, E. G. Waldmann; 24, C. H. Smiley; 25, Mrs. Welch; 26, Miss M. Harwood; 27, L. Holloway; 28, J. Welch; 29, Miss A. Farnsworth; 30, R. N. Mayall.

31, Mrs. Smiley; 32, J. Ruiz; 33, Mrs. V. Nail; 34, M. Kimball; 35, R. Wright; 36, R. Hamilton; 37, Mrs. Ford; 38, Miss A. Walker; 39, Mrs. J. Dishong; 40, J. Ashbrook.

41, Miss K. Hendrie; 42, Miss D. Hoffleit; 43, P. W. Witherell; 44, F. Pflug.

The sixth annual convention of Western Amateur Astronomers at San Francisco. Photograph by C. Rattenbury.

Sixth Annual Convention of Western Amateur Astronomers

AMATEUR ASTRONOMERS from 15 societies in Arizona, California, Nevada, and New Mexico gathered in San Francisco on August 27-29 for the sixth annual convention of the Western Amateur Astronomers. Hosts to the meeting were the San Francisco Amateur Astronomers.

THIS MONTH'S MEETINGS

Chicago, Ill.: Burnham Astronomical Society, 3 p.m., Adler Planetarium. Dec. 12, Albert V. Shatzel, Adler Planetarium, "The Satellites of the Solar System."

Cleveland, Ohio: Cleveland Astronomical Society, 8 p.m., Warner and Swasey Observatory. Dec. 10, Dr. W. W. Morgan, Yerkes Observatory, "The Structure of Our Galaxy."

Dallas, Tex.: Texas Astronomical Society, 8 p.m., Dallas Power and Light Co. auditorium. Dec. 27, Ted F. Gangl, "Visitors from Outer Space."

Geneva, Ill.: Fox Valley Astronomical Society, 8 p.m., Public Library. Dec. 14, John Sternig, Glencoe Public Schools, "Space Travel."

New York, N. Y.: Amateur Astronomers Association, 8 p.m., American Museum of Natural History. Dec. 1, Prof. Antares Parvulescu, Bard College, "It Ain't Necessarily So."

and W. Arp, at Mount Wilson and Palomar Observatories; D. B. McLaughlin's interpretation of surface features of the planet Mars as wind-blown volcanic debris; the June 30th total eclipse of the sun, and in particular the eclipse observations for geodetic purposes, sponsored by the U. S. Air Force; and the extensive support of American astronomy by the National Science Foundation, the Air Force, the Navy, and the National Bureau of Standards. J. A.

The meeting began at the Randall Junior Museum, where there were numerous exhibits of amateur-made telescopes and photographs, and daylight demonstrations of Airy diffraction patterns and model double stars. That evening the group visited Chabot Observatory, where clouds prevented observations with the 20-inch refractor, but Ronald Royer's Kodachrome slides of the previous convention, with T. A. Cragg's commentary, provided an enjoyable program.

The Saturday morning session was devoted to papers on instruments and accessories. W. A. Anderson spoke on glass, F. B. Wright described some variations of the Ronchi test, and A. S. Leonard spoke on apodizing screens. That afternoon, the pronunciation of astronomical names was discussed by H. W. Milner; Natalie R. Leonard and C. O. Dickey talked about books for the amateur, and a paper on lunar bands by the English selenographer, P. W. Moore, was read by D. P. Barcroft. The results of Martian observations in 1952 were reported by T. R. Cave, Jr., and Mr. Cragg told of observations by himself and others of the recently rediscovered outer ring D of Saturn. Eclipse experiences were recounted by several of the delegates.

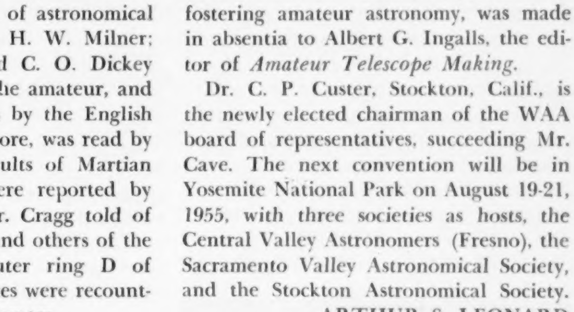
That evening, at the Morrison auditorium, Leon Salanave, of the planetarium staff, gave an illustrated account of his eclipse expedition to Norway. Following this, Dr. Bart J. Bok, Harvard Observatory, delivered the Morrison lecture, which turned out to be the highlight of the convention, on "Radio Signals from the Milky Way."

The closing day featured talks on telescope making by C. E. Wells and Mr. Anderson, and George W. Bunton gave a special demonstration of the capabilities of the Morrison Planetarium projector.

Miss H. E. Neall was mistress of ceremonies at the dinner Sunday evening. The first presentation of the G. Bruce Blair medal, for notable achievement in fostering amateur astronomy, was made in absentia to Albert G. Ingalls, the editor of *Amateur Telescope Making*.

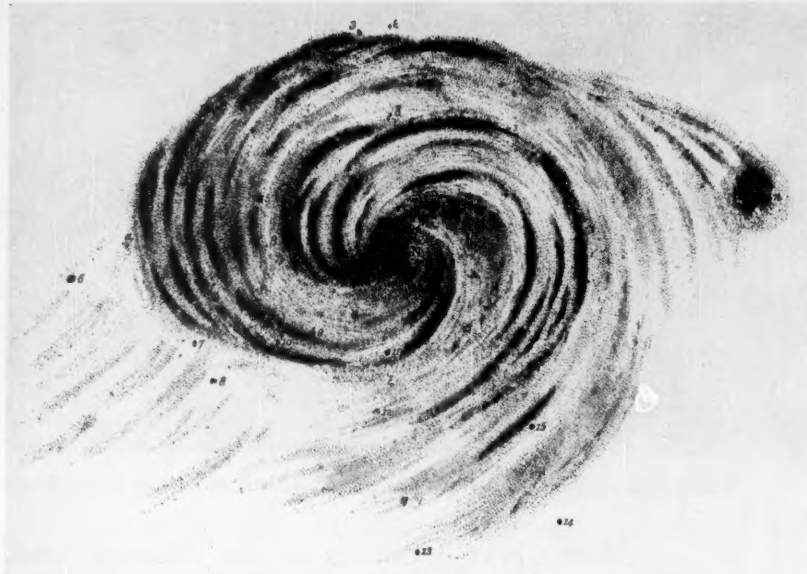
Dr. C. P. Custer, Stockton, Calif., is the newly elected chairman of the WAA board of representatives, succeeding Mr. Cave. The next convention will be in Yosemite National Park on August 19-21, 1955, with three societies as hosts, the Central Valley Astronomers (Fresno), the Sacramento Valley Astronomical Society, and the Stockton Astronomical Society.

ARTHUR S. LEONARD
Davis, Calif.



The first G. Bruce Blair medal, awarded to Albert G. Ingalls by the Western Amateur Astronomers. Photo by F. Kettlewell.

In Focus



Lord Rosse made this drawing of the Whirlpool nebula in 1850, with his 72-inch reflector at Birr Castle, Ireland. The spiral structure, earlier missed by Rosse with a 36-inch reflector, was first noted in the spring of 1845. The numbers label foreground stars, which are in our own galaxy.

THE CENTER PICTURE in this month's issue is an enlargement of a photograph of the famous Whirlpool nebula, taken with the 200-inch reflector at Palomar Observatory.

The main body of this great spiral galaxy is known as NGC 5194, and the companion mass to the north and slightly east (above and to the right) is NGC 5195. Together, they constitute No. 51 in the list of Messier, who in 1772 first saw here what he termed a faint double nebula, with centers $4\frac{1}{2}$ minutes of arc apart, but with their borders in contact.

Messier's is a fair description of what the amateur observer can make out visually, if he points his telescope to this object, in the constellation of Canes Venatici, at right ascension $13^h\ 27^m.8$, declination $+47°\ 27'$ (1950 co-ordinates).

Photographs with large telescopes, such as the 200-inch, show NGC 5194 as a magnificent open spiral galaxy, of Hubble's type Sc, whose arms are broken up into a wealth of starclouds, clusters, gaseous nebulosities, and individual stars. The brighter stars in the picture are all foreground objects belonging to our own Milky Way system, but the granular quality of the starclouds indicates their incipient resolution.

This photograph has been taken to bring out faint detail, and the bright central region is overexposed, so that the starlike nucleus does not show. A large, very faint extension of NGC 5194, to the left in the illustration, brings the angular dimensions of the whole complex to at least 12 by 6 minutes of arc.

The companion galaxy, NGC 5195, has been classified in different ways—as irregular, and as a peculiar elliptical type. Superimposed on its soft, nearly featureless texture are several dark streaks and patches, indicating obscuration by dust clouds associated with the system.

The distance of the Whirlpool nebula has been given as three million light-years, but the revision now in progress for the distance scale of the universe will presumably at least double this figure.

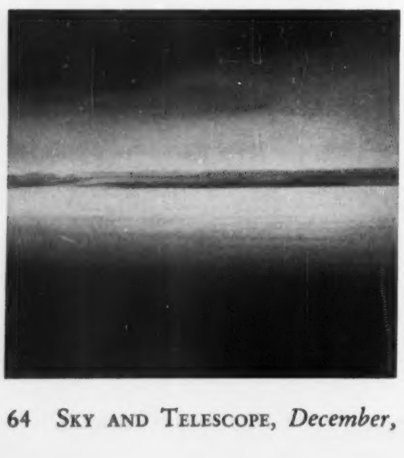
To NGC 5194 belongs the distinction of having been the first galaxy in which a spiral form was detected. This discovery was made by the Earl of Rosse in 1845, with his reflecting telescope of 72 inches aperture and 53 feet focal length, at Parsonstown, Ireland. His drawing of the visual appearance of the double system resembles modern photographs rather well. His was the largest amateur telescope ever built, and he made with it the lone important *visual* contribution to what we know of the nature of galaxies.

(The picture itself may be removed from the center of the magazine by opening the staples.)

LETTERS

Sir:

The accompanying photograph was obtained during the solar eclipse of June 30th from a jet aircraft, above the clouds in eastern Sweden and just after the moon's shadow had arrived. It shows a flat layer of stratocumulus clouds on which the shadow of the moon and the edge of the shadow are seen in the lowest part of the picture. The central part is sunlit, and in the distance the cloud layer is rough and darker. The edge of the shadow is again seen on the faint cirrus clouds near the top of the picture.



The height of the aircraft was 8,500 meters (28,000 feet) above the earth or about 7,000 meters above the top of the clouds. The photographer was Flight Lieutenant Thomas Andersson, Royal Swedish Air Force.

GUNNAR DARSENIUS
F 9, Goeteborg 1, Sweden

Sir:

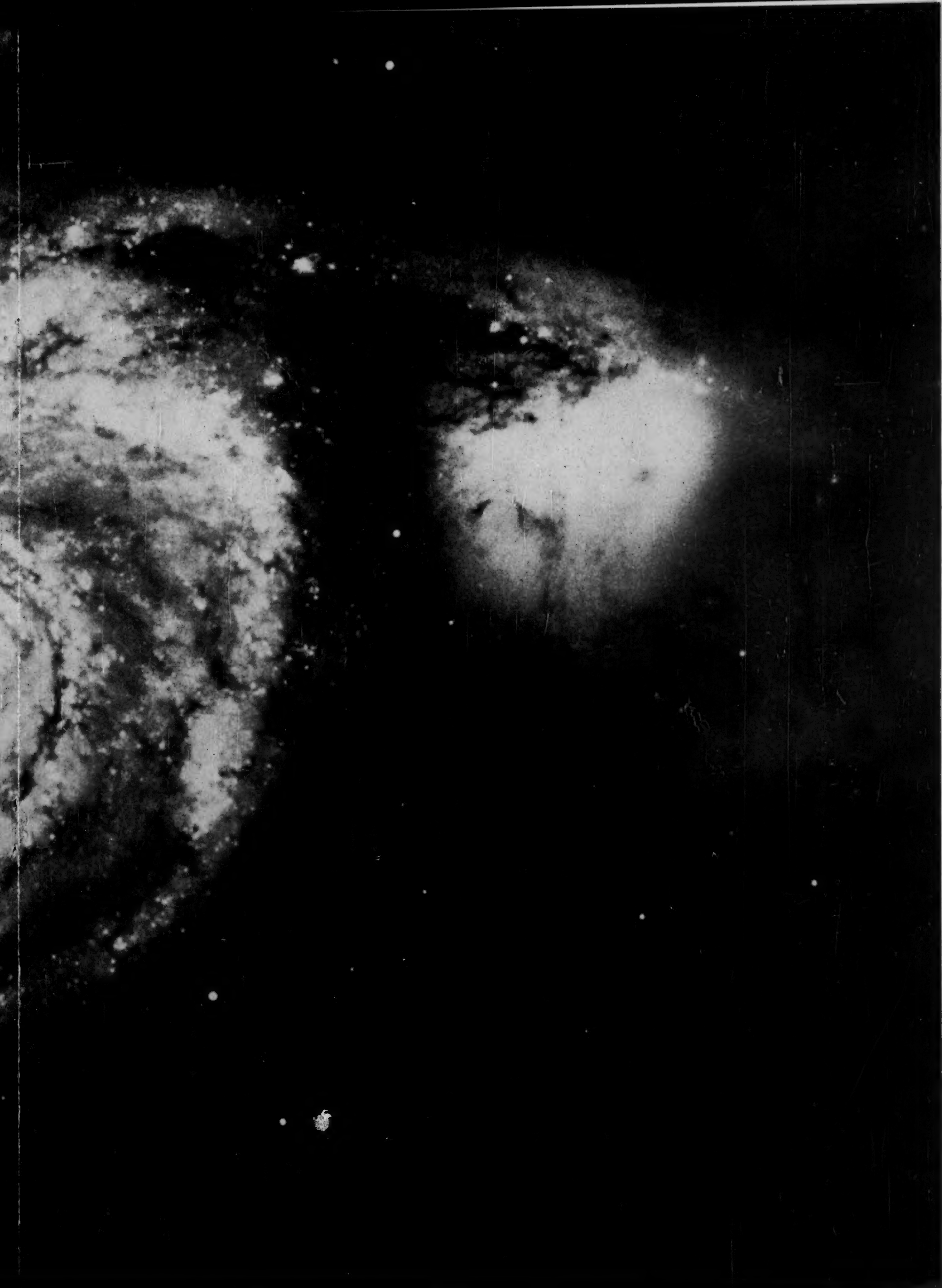
During the eclipse of the sun on June 30, 1954, I made an extensive study of the radio reception from Canadian longwave stations. My receiving apparatus was located at Opasatika, Ont., midway between Mattice and Kapuskasing. For purposes of comparison, the frequencies to be checked were received under day and night conditions on the three days preceding the eclipse.

Normal daytime reception in that area is very limited, with high noise levels. During the eclipse, however, reception was ideal. For a half hour before and after totality, all stations near and far that were located in or close to the path of totality furnished excellent reception. But after 8 a.m., all signals went into a rapid fade, and the normal daytime conditions again took over. Full details of this investigation, which included a radio-checking trip of 5,486 miles, will be published after all our logs are verified.

From letters received so far, it appears that many stations were heard in Opasatika for the first time in 20 years during the eclipse. Places that have always been considered dead areas, both day and night, were "alive" during totality.

A similar test is being tentatively planned to check radio reception from a radio station in the path of the annular phase, in South Africa, on December 25th. Christmas eve programs in this country may, however, interfere seriously with such long-distance reception.

DAVID F. THOMAS
Long Wave Listening Post
P. O. Box 1613
Proctorville, Ohio



BOOKS AND THE SKY

A BRIEF TEXT IN ASTRONOMY

William T. Skilling and Robert S. Richardson. Henry Holt and Company, New York, 1954. 327 pages. $4.00.

THE AUTHORS of some of the leading textbooks in astronomy have felt compelled to write shorter and more elementary texts for one-semester courses. This necessity is unfortunate, and it is to be hoped that in the near future nearly all colleges will devote a full year to the introductory course in astronomy, as is commonly done with the other sciences. But as long as the present state of affairs continues, there should be available, for the student who must take an abridged course, a textbook which presents briefly the essential facts of astronomy in such a manner as to arouse his interest and stimulate him to further study.

The larger textbook by Skilling and Richardson, which has gone through two editions, has been so favorably received that one may well expect to find the merits of that book equally conspicuous in this shorter one, and in this expectation we are not disappointed. As the authors remark, it is difficult to decide just what should be included of all the findings in the observatory, and how much can justifiably be given to students with little or no scientific background. In view of this, the collaboration of Professor Skilling, with many years of teaching experience, and Dr. Richardson, skilled in research at Mount Wilson and Palomar Observatories, seems particularly fortunate.

The treatment is sufficiently elementary for a student with a minimum of mathematics and physics. Clarity of expression and a conversational style are outstanding features. The illustrations, mostly photographs taken at Mount Wilson and Palomar, are numerous and well chosen. Particular pains seem to have been taken with the many diagrams, and the exercises at the end of each chapter are helpful and thought-provoking.

The book appropriately begins with the astronomer's tools, including the different types of telescopes and accessories. The importance of constellation study for the beginner is stressed, and star maps for each month of the year are included at the back of the book. The diagrams and explanations of the Foucault pendulum and of precession are particularly helpful. The horizon and equatorial systems of co-ordinates are clearly explained, the ecliptic and galactic systems being omitted. Tides, a topic frequently slighted in elementary texts, are well presented.

The chapters on the sun and planets are up to date, and include recent results on solar flares and microwave radiation from the sun. In contrast to the usual description of sunspots as vortices or cyclonic disturbances, they are compared to "cool springs of water overflowing onto a desert." The discussion of Mars is of particular interest. The diagram illustrating the orbits of Jupiter's satellites shows strikingly the departure from regularity of the outermost satellite orbits.

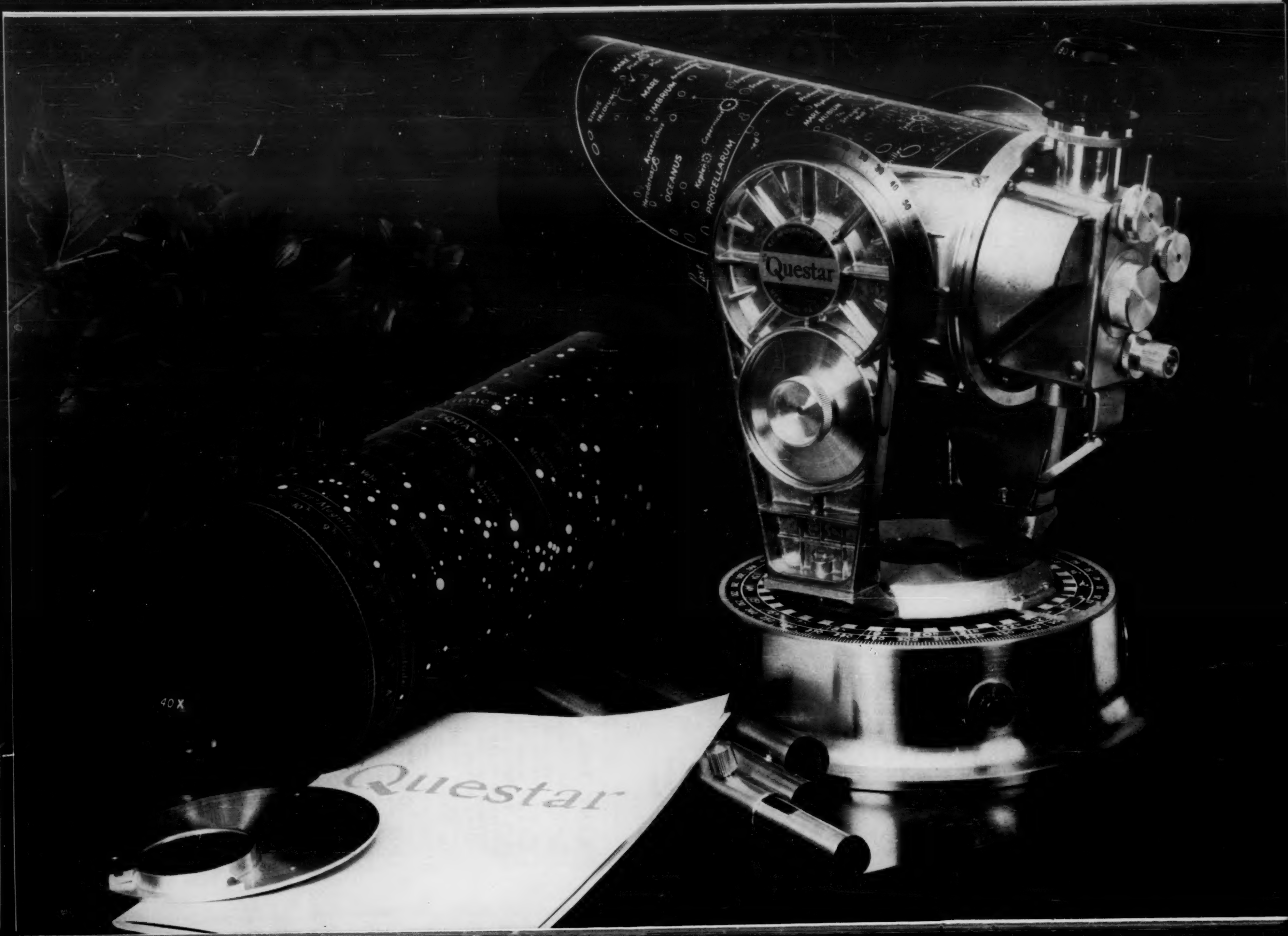
The point has often been raised that most textbooks on astronomy devote a disproportionate space to the solar system, slighting the stars which are the chief concern of modern astronomy. Somewhat less than one third of the present book is given to the stars and galaxies, and one might wish that a little more space were allotted to stellar astronomy, but this is perhaps not feasible in an elementary text.

The authors have tried to include some of the advances in special fields too recent to be generally known. We find included the two types of Cepheids, the two stellar populations, and the revision of the distance scale that has resulted from Baade's work. The carbon cycle and the proton-proton reaction are explained in terms understandable to the beginning student.

There are only a few points to which exception might be taken. All temperatures — solar, planetary, and stellar — are expressed in terms of the Fahrenheit scale. It would seem more appropriate to use the centigrade scale, as this is employed exclusively in scientific work. The meaning of the term *mass,* usually not clearly understood by beginners, might be explained when it is introduced in connection with the law of gravitation.

In the discussion of telescopes, there is no mention of resolving power, nor is it explained how the magnifying power depends upon the focal lengths of the lenses employed.

A few errata may be noted. On page 42, Bode was the editor of the *Berliner Astro-*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nomische Jahrbuch and not the *Astronomical Journal.* On page 243, Eggen's star, SX Phoenicis, rather than CY Aquarii, is now the variable star of shortest known period; and on the following page, the longest-period Mira stars have periods of more than 1,000 days, rather than 700 days.

The authors remark that it is unfortunate that the term *nebula* is applied both to the gaseous clouds of our galaxy and to stellar systems far beyond our own. Nevertheless, they refer to the distant systems as *extragalactic nebulae.* It would seem better to restrict the term nebula exclusively to gaseous objects like those within the Milky Way, and refer to the distant systems always as *galaxies* or *exterior systems.*

On the whole, the book fulfills its purpose admirably, and not only the beginning student but many of the general public can find here the basic facts of astronomy clearly and often strikingly presented.

DAVID VANCE GUTHRIE
Louisiana State University Observatory

A HISTORY OF THE THEORIES OF AETHER AND ELECTRICITY, 1900-1926

Sir Edmund Whittaker. Philosophical Library, New York, 1954. 319 pages. $8.75.

BENEATH the formidable title of Sir Edmund Whittaker's latest volume lies an enormous fund of information about the progress of theoretical physics in the first quarter of this century. Subtitled "The Modern Theories" (to differentiate it from volume I, "The Classical Theories"), it might have been more lucidly called "A History of Relativity and Quantum Mechanics."

Starting with "The Age of Rutherford," the history moves rapidly through radioactivity and X-rays to a chapter on special relativity, and then into quantum theory. In fact, the major part of the book considers the older quantum theory, matrix mechanics, and wave mechanics. An exception is a long chapter essentially on the general theory of relativity, under the heading "Gravitation." This fifth chapter is of particular interest to astronomers.

Fortunately, Sir Edmund does not limit this volume to the span of 26 years, but sketches in the background of the material, and he frequently presents recent work. In the chapter on gravitation, he outlines the work on several secular inequalities which have troubled such celestial mechanicians as Laplace, Lagrange, and Euler, as well as more modern workers. Among these is the advance of the perihelion of Mercury, for which Dr. Whittaker points out two possible explanations besides general relativity. This is the only quantitative test substantiating the general theory of relativity, according to Dr. Whittaker, who states that eclipse measures of the bending of light rays around the sun show a discordance with Einstein's theory. He also rejects as a valid test the displacement of spectral lines in a strong gravitational field, stating that this was explained before general relativity.

In many ways this book is a recital of one discovery after another, and we must thank the author for his careful listing of journal references, found in footnotes on nearly every page. However, most modern historians agree that history is a study of interpretations, rather than of facts, and that the historian's own personality inevitably colors his selection of material. This is not an unmixed blessing in the present case, for the reader meets both the advantages and disadvantages of the author's tre-

mendous technical background. No one can deny that his own contributions and long-standing rapport with modern physics make him eminently qualified to discuss the growth of this science.

The result is a volume of interest primarily to those familiar with differential geometry and the mathematics of quantum mechanics. It cannot expect to compete for the attention of any nonmathematical reader, except as a reference work. But a book with so much potential value for reference should certainly have a subject index two or three times as detailed as this one.

Dr. Whittaker's special interests show through his history in a number of other ways. For instance, he states that the fine-structure constant has now "been found to be 1/137." Anyone acquainted with Dr. Whittaker's defense of Eddington's work on *Fundamental Theory* will realize that this is one of his special interests. From purely theoretical considerations, Eddington decided that this fundamental constant of quantum mechanics must be exactly 1/137. There has been considerable controversy as to whether the value is exactly that or ever so slightly off this figure. Recent experimental work by W. E. Lamb shows quite strongly that it cannot be exactly 1/137. Hence, Dr. Whittaker's statement seems eligible for at least a conditioning adverb or clause.

Again, many historians of science will be surprised to see the periodic table of the elements referred to as the "Newlands-Mendeleev" table. Newlands, a 19th-century English chemist, was one of the first to study the periodicity of the elements. His ideas were expanded by the Russian, D. I. Mendeleev, and independently by the German, Lothar Meyer, and it is these two who are generally credited with the development. Meyer's name does not appear in the book, however.

Another somewhat different emphasis comes out in the discussion of special relativity under the heading "The Relativity Theory of Poincaré and Lorentz." Whittaker points out that Poincaré enunciated the principle that no velocity can exceed the speed of light in a lecture in St. Louis in 1904, and as early as 1900 had suggested the now famous equation, $\mathbf{E} = \mathbf{mc}^2$. Einstein rates a mere handful of references in this chapter; nevertheless, in the index the book does list more references to Einstein than to any other scientist.

A History of the Theories of Aether and Electricity goes a long way to give us a systematic account of the key developments in theoretical physics on a more technical level than popular books covering some of the same territory. Dr. Whittaker answers the question of how to present a survey of modern physics by an unhesitating use of mathematics. Whether a good book straddling the gap between complete simplification and the forest of mathematics can be written remains to be seen.

OWEN GINGERICH
Harvard College Observatory

NEW BOOKS RECEIVED

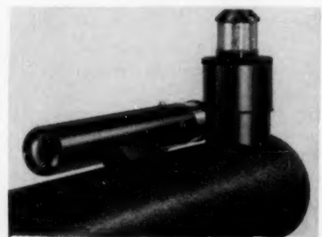
INTRODUCTION TO ASTRONOMY, *Cecilia Payne-Gaposchkin*, 1954, *Prentice-Hall*. 508 pages. $8.00.

Mrs. Gaposchkin states in her preface, "This book is intended to introduce the elements of astronomy to the student and to the general reader who may have little background in mathematics or physics.

"My chief reason for writing the book was a desire to give emphasis to stars and stellar systems as well as to the solar system, which usually occupies the major part of an elementary book."

The BRANDON
3-inch Astro Altazimuth Refractor

Focusing Eyepiece



Finder Telescope

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Including tripod, finder, carrying case and one of our orthoscopic oculars of your choice. Focal lengths available: 32, 16, 8, and 4 mms.

- Excellent optical design. All aberrations fully corrected. Superior optical glass. Air-spaced objective. All surfaces hard-coated.
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- Exposed focal plane for photography. Erect image for terrestrial observation. Six internally spaced baffles completely eliminate internal reflections which cause "ghosts" and loss of contrast.
- All-metal altazimuth mounting. No springs on altazimuth pin. Velvet-smooth bearings. Elevation bearings 2½". Azimuth bearing 5¼". Sturdy ribbed aluminum casting, permitting comfortable zenith observation.
- Dural tripod legs. Stainless steel pins. Rugged plywood carrying case holds telescope and accessories securely in position when closed.
- Attractively finished in baked enamel or anodized Dural. No parts can be damaged, rusted, or tarnished if left out in the weather.

NOTE: Because we produce the entire telescope, lenses and accessories, ourselves—pay no duties or commissions to importers or dealers—we can sell this superb telescope for $196.00. Immediate delivery—Shipment express collect. Send check or money order. No C.O.D.'s.

Chester Brandon

BOX 126 MONTROSE, CALIFORNIA

GLEANINGS FOR ATM's

EDITED BY EARLE B. BROWN

A 6-INCH F/10 SPRINGFIELD REFLECTOR

HAVING TIRED of climbing up to the eyepiece end of my old 6-inch Newtonian, I decided to build a Springfield mount.

The heart of the mounting is a 7″ by 7″ by $\frac{1}{2}''$ piece of structural angle iron, reinforced with gussets. I rounded the corners to a $3\frac{1}{2}''$ radius for appearance. The saddle is a 24″ length of 6″ channel, in which a hole was drilled to take the hollow declination axis, a 3″ length of $1\frac{1}{4}''$ pipe nipple. The nipple was first screwed into a floor plate (with its threads reversed), inserted into the hole in the saddle, and then the floor plate was welded to the saddle. An extension of the saddle past the open end of the telescope tube holds a $1\frac{1}{4}''$ pipe that carries the counterweight. This extension was made long enough to give room for the observer's head when the telescope is pointed toward the northern sky.

The backs of the angles were faced off to a true 90 degrees, and the back of the channel was faced off also.

The bearing surfaces are two discarded bronze truck thrust rings 7″ in outside diameter and 3/16″ thick; they are mounted on the faces of the angle iron with countersunk brass bolts. The rings were lapped with grinding compound, one against the back of the channel, the other against a faced-off base plate, $\frac{1}{2}''$ thick, that holds the $\frac{3}{4}''$ stud bolt that is my polar axis.

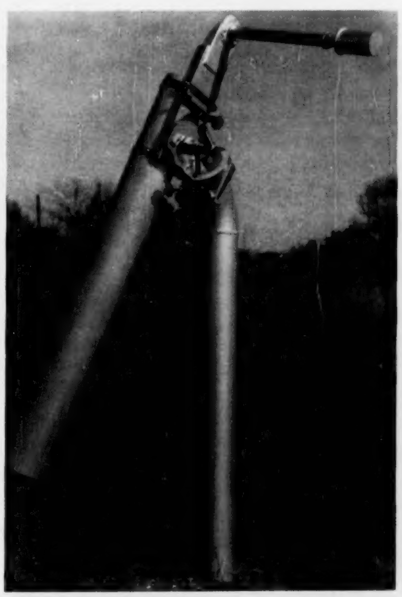
The "slow motions" are simple cam-shaped brass sheets inserted between the declination and right ascension bearing surfaces. They allow the tube to be swung by hand at any time, since the telescope is held by friction and not by clamps.

The 5′ tube is aluminum, 7″ in outside diameter. My pedestal is 6″ pipe with a welded 45° elbow at the top; the footing is a 750-pound concrete block extending 2′ into the ground.

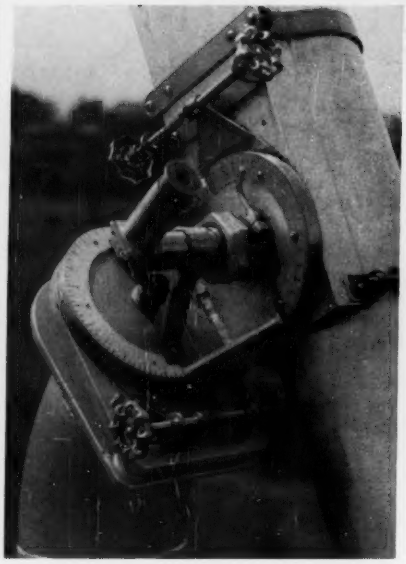
The 90-degree eyepiece holder, which provides a convenient position for the observer's eye regardless of where the telescope is pointing, was made from $1\frac{1}{2}''$ inside diameter hard copper water pipe. Two sections of this pipe hold the diagonal assembly, and the horizontal section slides nicely into the $1\frac{1}{4}''$ pipe nipple.

I had poor definition using prisms, but changing to a $\frac{1}{8}$-wave elliptical pyrex flat for the main diagonal cured the trouble. My advice to anyone making a Springfield is to use a good flat. Since it must be placed about twice as far inside the primary focus as in a Newtonian, the flat must be of much better quality.

This instrument is extremely rigid, and the fixed position of the eyepiece is well worth the extra effort involved. The total cost, including welding and machining, was under $85.00, not counting the mir-



A Springfield-mounted 6-inch reflecting telescope, built by Oscar R. Knab, of South Bend, Ind.



A closeup of Mr. Knab's mounting.

ror itself. I have also installed circles made from 6" plastic protractors, which are quite suitable for locating celestial objects.

OSCAR R. KNAB
R. R. 6, Box 23
South Bend, Ind.

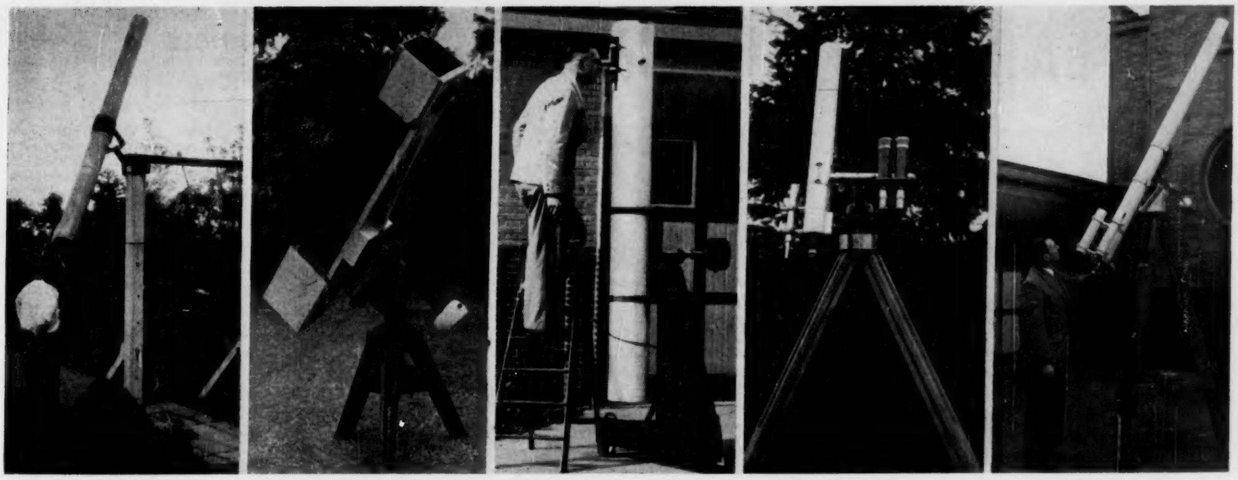
NEWS FROM BELGIUM

THE GRINDING of my first mirror began during the last years of World War II. At that time carborundum and emery were hard to find here in Belgium, so I made a 3-inch mirror for experience before tackling a 6-inch pyrex disk. This proved a very satisfactory mirror, but I went on to make a total of 16 of them. The largest is a 10-inch, f/6.3, which I am now parabolizing.

Contrary to usual ATM practice, all my mirrors have been polished on paper laps. The polishing has been continued until pits were thoroughly worked out. This took only five hours for my 10-inch mirror. To tell when polishing is complete I check with a microscope under powers of 35 and 80.

It is strange that paper polishing has been so largely abandoned for pitch by amateurs and professionals alike. Old masters like Foucault got excellent results with paper laps. I stay "on paper"; it gives neat work and needs very little rouge. Nevertheless, I use pitch for figuring, because a pitch lap is easy to refashion.

Most of my mirrors are long focus, usually f/10 or f/11 and in one case f/15, to avoid the necessity of parabolizing them. Experienced ATM's are familiar with the fact that a 6-inch, f/10, spherical mirror, for example, will give images as good as if it had been parabolized to $\frac{1}{4}$ wave length. The only difference is in the appearance of the diffraction pat-



Some of Harry de Meyer's telescopes are shown here, left to right: The 5.6-inch long-focus refractor is excellent for planetary observations. The 4.8-inch Newtonian is finished spherical at f/10. The 8-inch Newtonian has a pyrex mirror, and a focal length of 83 inches; this instrument is on a German mount with a counterweight, and the slow motion is hand driven with a flexible cable. The fourth telescope is a 2.4-inch refractor, with the unusual feature of a pair of 60-mm. binoculars mounted as a counterweight; it has a hand-driven slow motion. The telescope at the right is another 5.6-inch refractor, with two finders, one 9x and the other 24x; it weighs 170 pounds and is easily rolled outdoors.

tern when the eyepiece is a few millimeters inside the focus. In both cases the focal image of a star will be a point surrounded by one or more rings. Of course, making a paraboloid gives an esthetic satisfaction that making a sphere does not.

My 4.8-inch Newtonian shown here is handy to take on trips. The use of pipes in the equatorial head was suggested by American telescopes, and the "letter-box" tube construction is one widely used by Swiss amateurs.

My 8-inch Newtonian, with a pyrex mirror of 83 inches focus, has given fine performance. The appearance of the diffraction rings around a star is the same inside and outside the focus. This telescope shows the fifth star in the Trapezium in the Orion nebula.

For planetary work my most efficient

LARGE OBJECTIVES

ACHROMATIC TELESCOPE OBJECTIVES

These are perfect magnesium-fluoride coated and cemented Gov't. surplus lenses made of finest crown and flint optical glass. They are fully corrected and have tremendous resolving power. They can readily be used with eyepieces of only 1/4" focal length, thereby producing high powers. Guaranteed well suited for astronomical telescopes, spotting scopes, and other instruments. Gov't. cost up to $100 and more.

Diameter	Focal Length	Each	Diameter	Focal Length	Each
54 mm (2 1/8")	300 mm (11.811")	$12.50	83 mm (3 1/4")	660 mm (26")	$28.00
54 mm (2 1/8")	330 mm (13")	12.50	83 mm (3 1/4")	711 mm (28")	28.00
54 mm (2 1/8")	390 mm (15.356")	9.75	83 mm (3 1/4")	762 mm (30")	28.00
54 mm (2 1/8")	508 mm (20")	12.50	83 mm (3 1/4")	876 mm (34 1/2")	28.00
54 mm (2 1/8")	600 mm (23 1/2")	12.50	83 mm (3 1/4")	1016 mm (40")	30.00
78 mm (3 1/16")	381 mm (15")	21.00	110 mm (4 3/8")*	1069 mm (42 1/16")	60.00
81 mm (3 3/16")	622 mm (24 1/2")	22.50	110 mm (4 3/8")	1069 mm (42 1/16")	67.00

*Not coated

• We can supply ALUMINUM TUBING for the above lenses. •

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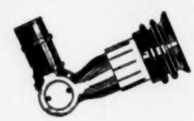
Known among amateurs as the "Giant Jaegers", this is the finest wide-angle eyepiece ever made. It gives a flat field. It is mounted in a focusing cell. It has three achromatic lenses, 1 1/2" effective focal length, with a clear aperture of 2". It may be used as a Kodachrome viewer, magnifying seven times.

$125.00 Value $12.50

Wide-angle eyepiece as above, with 1 3/16" aperture and 1 1/4" E.F.L. $13.50

3X ELBOW TELESCOPE



Makes a nice low priced finder. Brand new; has 1" Achromatic Objective. Amici Prism Erecting System, 1 3/8" Achromatic Eye and Field Lens. Small, compact, and light weight, 2 lbs.

Gov't. Cost $200.

Plain Optics $9.75 Coated Optics $12.50

8X ELBOW TELESCOPE

This telescope will make an exceptional finder. Objective 52 mm diameter. Focusing eyepiece, turret-mounted filters, amber, red, neutral, and clear. Illuminated cross-line reticle, quick-finding level sight, and large-size Amici prism.

Used ....$18.50 Brand New $27.50

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For stargazing and terrestrial use. It gives an upright image. Large coated achromatic objective 60-mm diameter. Tripod constructed of wood with brass extension tubes. Tube 22" when closed, 56" fully extended. Swivel mount can be locked in any position. $39.75

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8" x 10"	1/4"	4.25
4" x 5"	1/4"	1.85
4" x 4"	1/4"	1.50
1 1/4" x 1 1/2"	1/16"	.25

RIGHT-ANGLE PRISMS

These may be used for astronomical telescopes, for direct positive photography, and for other purposes.

8 mm Face	ea.	$ .75
12 mm Face	ea.	.75
23 mm Face	ea.	1.25
30 mm Face	ea.	1.75
38 mm Face	ea.	1.75
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12 mm x 17 mm Face .... ea. $ .75

18 mm x 25 mm Face .... ea. 1.50

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26 mm x 27 mm Face .... ea. $3.50

LARGE PORRO PRISM

91 mm x 41 mm x 64 mm ...... ea. $4.00

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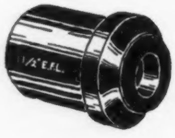

We have a large stock of precision war surplus lenses, and have mounted them in precision mounts of 1 1/4" outside diameter, the standard for telescopes. Result! You would pay several times more elsewhere. Our prices can't be beat.

12.5 mm (1/2") F.L. symmetrical eyepiece contains two cemented achromats.
Coated lenses $6.75 Not coated $6.00

16 mm (5/8") F.L. extra wide angle Erfle contains five lenses.
Coated lenses $13.50 Not coated $12.50

16 mm (5/8") F.L. triplet eyepiece contains a three-element lens and a simple lens.
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18 mm (3/4") F.L. symmetrical eyepiece contains two cemented achromats.
Coated lenses $6.75 Not coated $6.00

22 mm (27/32") F.L. Kellner eyepiece contains cemented achromat and a non-achromatic lens.
Coated lenses $6.75 Not coated $6.00

32 mm (1 1/4") F.L. eyepiece contains two achromatic lenses.
Coated lenses $13.50 Not coated $12.50

35 mm (1 3/8") F.L. symmetrical eyepiece contains two cemented achromats.
Coated lenses $8.75 Not coated $8.00

55 mm (2 3/16") F.L. Kellner eyepiece contains achromatic field lens and a non-achromatic eye lens.
Coated lenses $6.75 Not coated $6.00

A. JAEGERS

691S Merrick Road
LYNBROOK, N. Y.

telescope is a 5.6-inch refractor with the unusually high focal ratio of f/24.6. The instrument is dismounted when not in use. With a 380x eyepiece, I once was able to see six of Saturn's satellites. Another 5.6-inch refractor of shorter focus is more convenient for general purposes. One of its two finders, with a 3-inch objective and a 9x Erfle-type wide-field eyepiece, is particularly well suited for picking up nebulae.

The damp and foggy Belgian weather does not allow these instruments to perform as efficiently as they would in more favorable locations. Atmospherically, our situation may be compared with that of the Aleutian Islands, which are in the same latitude!

HARRY DE MEYER
Prins Leopoldstr. 22
Sint-Kruis-Bruges, Belgium

A HINT FOR TELESCOPE USERS

An Antidiffraction Mask. Users of reflecting telescopes are familiar with the troublesome diffraction pattern surrounding a star that is caused by the telescope diagonal and its supports. The "crosses" on the images of bright stars in reflector photographs are caused by the strut support diffraction. If the obstructing object is far away, as in the case of the branches of a leafless tree in winter, a star may even appear multiple because of diffraction.

Within the telescope, you can avoid the effect of this diffraction by placing directly on the mirror a piece of black paper, large enough to block out the shadow of the diagonal and its supports, as cast on the mirror when the telescope is pointed to the sun. Allow 3/16 of an inch to spare all along the shadow, and secure the paper at the edges of the mirror by Scotch tape.

The very slight diffraction occurring at the edges of the paper I estimate to be not two per cent of what the diagonal and its supports would otherwise cause. As a result, telescope performance is comparable to that obtained with an off-axis telescope. Circular struts do not eliminate diffraction but increase it, yet the circular pattern is less noticeable than the "rays" that straight struts add to a star image.

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Designed by us to meet every need of the amateur astronomer! Specially engineered not only for blueprint precision, but for comfort, ease of operation and freedom from mechanical restrictions! 4¼" mirror **guaranteed** to give theoretical limit of resolution. Diagonal and combination eyepiece finished to equal or better tolerances than mirror. Look at all these revolutionary features: Rack and pinion, micrometer-smooth focusing with tension adjustment. Two-piece rigid diagonal construction. All-aluminum black anodized tube. No-distortion adjustable mirror mount, easily removed for mirror cleaning. Tube ventilated. **Real** equatorial mount—one smooth motion follows stars, planets. Sturdy hardwood tripod. Counterweight for perfect balance. Latitude adjustment easily made with tripod setting.

Technical specifications: mirror aluminized, overcoated with silicon monoxide. Focal ratio f/10.5. Focal length 45". Combination eyepiece gives powers of 57X (20 mm.) and 115X (10 mm.). A 6-mm. eyepiece, available from us at extra cost, gives 190 power. All eyepieces are standard 1¼" diameter. Focus travel of eyepiece mount is 2¼". Tube finished in jet black, accessories in black wrinkle finish. Tripod stained natural wood.

Stock No. 85,006-Y .... complete .... $74.50 f.o.b. Barrington, N. J.

"MAKE-YOUR-OWN" 4-1/4" MIRROR KIT

The same fine mirror as above, polished and aluminized, lenses for eyepieces and diagonal. No metal parts. **Stock No. 50,074-Y** **$16.25 Postpaid**

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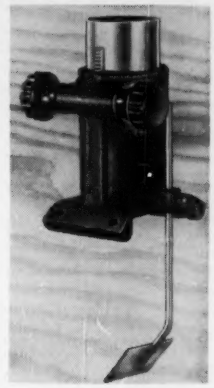
. . . Available with Diagonal Holder



Now—you can improve performance in a most important part of your telescope—the eyepiece holder. Smooth, trouble-free focusing will help you to get professional performance out of your present telescope whether you bought it "ready made" or built it yourself! Look at all these wonderful new features: Real rack and pinion focusing, with variable tension adjustment, gives you microscope-smooth focusing action. Focus travel over 2". Drawtube accommodates standard 1¼" eyepieces, giving your present telescope a wide, varied range of power. Standard size opening also allows the use of accessory equipment, such as sunspot projectors, filters, eyepiece prism diagonals and terrestrial erectors. Lightweight aluminum body casting. Rigid mounting achieved by drilling four small holes in tube, whether paper or metal. Drawtube and rack chrome plated brass, body in black wrinkle finish.

Add beauty and ease of operation to your present telescope—at low cost!

Stock No. 50,077-Y .... Only $8.95 Postpaid

DIAGONAL HOLDER

Designed as an accessory to the eyepiece holder. Single screw centers the diagonal in any size tube up to 8". Accurate 45-degree angle eliminates excessive preliminary adjustments. Rigid one-piece construction of rod makes frequent changes of adjustment unnecessary, allows more light to reach mirror. Includes double-faced adhesive tape to attach front surface mirror to plate—set it and forget it!

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TELESCOPE EYEPIECE — Consists of 2 Achromatic lenses. F.L. 28 mm. in a metal mount.
Stock No. 5140-Y.. $4.50 Postpaid
Same as above but about 1¼" extension has been added with O.D. of 1¼", which is standard.
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50x MICROSCOPE & 10x TELESCOPE

New 2 in 1 combination! Pocket size! No larger than a fountain pen. Sharp focus at any range. Handy for sports, looking at rare objects or just plain snooping.
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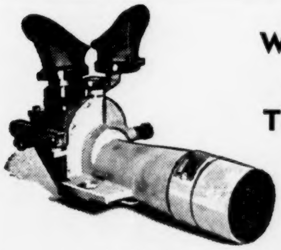

War Surplus ELBOW TELESCOPE M-7

8 Power

U. S. Govt. cost about $300.00!

Cemented achromatic doublet objective, F.L. 8⅝", speed f/4.5, clear aperture about 45 mm. F.L. of eyepiece 27 mm. Amici roof prism erector. Eye relief 25 mm. Field of view 6°. Length 12", width 5", height 6". Weight 3¾ lbs.
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Polished surfaces flat to ½ wave length. Angle tolerances 5 minutes. Dimensions of polished surfaces 18 mm. x 30 mm. Made from dense flint glass, free of striae and strain.
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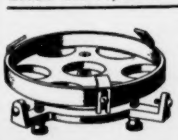

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Cast aluminum with brass mounting and adjusting screws and mirror clamps. Two sizes: for 6" mirrors —mount will fit 7" I.D. tube:
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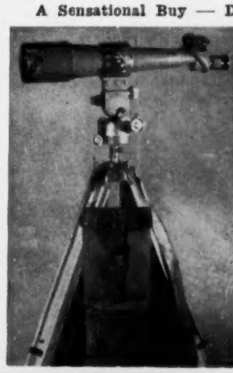

Eyepieces for 15, 23 and 30 power mounted on a rotating turret. Parfocal. 3" dia. achromatic objective. MOUNT: Rotates 360° in azimuth. Bubble level on elevation control. Instrument has prism-erecting system — brass construction. Length 20". Max. height 72". Used but in good condition. Comes with leather carrying case for telescope and mount; fiber case for tripod.

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OBSERVER'S PAGE

Universal time is used unless otherwise noted.

DEEP-SKY WONDERS

MOST DIFFUSE NEBULAE are known to amateurs only from photographs. Yet many are within reach of the amateur telescope and available to all who have learned the two rules of nebular work—clear skies and the use of averted vision.

Not many degrees away from the Great Nebula in Orion is the seldom observed nebula surrounding the Pleiades. The most easily glimpsed part is IC 349, first seen in 1859 by W. Tempel with a 4-inch, who described it as a faint stain 35′ by 20′, extending southward from Merope. For some years a controversy raged about its existence and that of other nebulosities in the Pleiades, but finally photographs confirmed Tempel's discovery.

The Merope nebulosity was discovered visually and still can be seen visually. In December, 1951, this column related the problem, and several amateurs wrote in that they could see the nebula. George T. Keene reported that on December 1 and 9, 1951, he saw definite nebulosity, with a 6-inch at 45 power, around Merope, Electra, and Maia, but not around Celaeno. I would like to hear more from observers on their own experiences with this object.

Nearby is Hind's variable nebula, NGC 1555, at 4^h $19^m.1$, $+19°$ $25'$ (1950), just outside the Hyades, and associated with the variable star T Tauri. It was found on October 11, 1852, by J. R. Hind, who is also remembered as the discoverer of 10 asteroids, many variables, and of some very red stars. The nebulosity varies in shape and brightness, but is often within reach of a good 6-inch. It is too small, however, to be noticed with a 6-inch rich-field instrument. The AAVSO chart of the T Tauri field affords a good means for locating this object. High powers seem to work best, and my clearest views of Hind's nebula have always come with powers of 100 to 300 on a 10-inch reflector.

A very similar small diffuse nebula is NGC 2261, 6^h $36^m.4$, $+8°$ $46'$, around the variable star R Monocerotis. This nebula is also variable; in recent years it has been more easily seen than NGC 1555, but it again requires powers of over 100 to reveal much detail.

The ability of some nebulae to bear high powers, indeed to require them, while others fade out immediately with magnification, is a problem to which no final answer has appeared. In general, the wise observer will always try high powers just to be on the safe side.

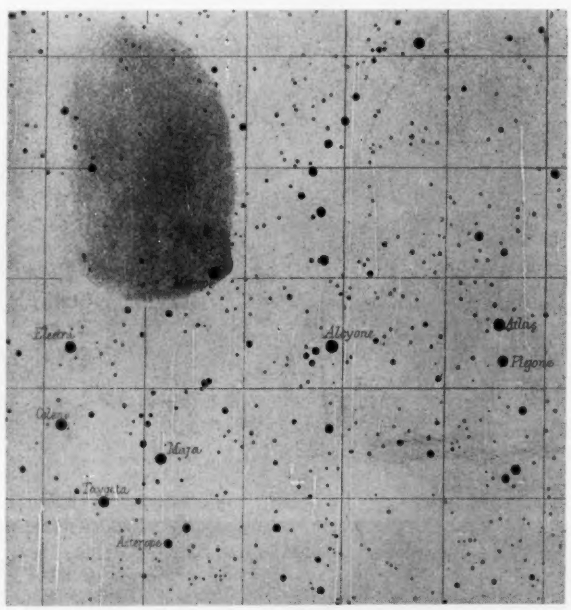
WALTER SCOTT HOUSTON

DECEMBER METEORS

Observations of the Geminid meteor shower, which reaches its maximum on December 12th, will be hampered by a bright moon in Gemini several days past full. This shower is rich enough to be observed, however, for rates up to 60 per hour have been noted under favorable conditions. The Geminids may be seen a week before and after maximum, principally before. They are medium speed, white, with some bright and trained meteors. The radiant is near the star Castor.

Lunar conditions for the December Ursids will be good at maximum on the 22nd. Predicted rates are 12 per hour, but this shower has not been as extensively observed as others.

This has been a poor year for meteors, for the moon has interfered with several showers; next year we will be much more fortunate. E. O.



Wilhelm Tempel, who discovered the large faint nebula extending southward from Merope, made this drawing of it at Milan Observatory. He described its appearance as like the faint stain of breath on a mirror.

SUNSPOT NUMBERS

September 1-3, 0, 0; 4, 2, 7; **5,** 2, 0; **6,** 1, 0; **7-13,** 0, 0; **14,** 1, 0; **15,** 1, 7; **16,** 0, 9; **17-19,** 0, 0; **20,** 0, 7; **21-29,** 0, 0; **30,** 1, 6. Means for September: American 0.3; Zurich 1.2.

Above are given the date, the American number, then the Zurich number. These are observed mean relative sunspot numbers, the American computed by D. W. Rosebrugh from AAVSO Solar Division observations, the Zurich numbers from Zurich Observatory and its stations in Locarno and Arosa.

The Swiss Broadcasting Corporation regularly transmits by short wave the Zurich provisional sunspot numbers for the preceding month. Listeners in North America can receive these reports on the 5th of each month at 01:35 and 03:20 UT on 49.55, 48.66, and 31.46 meters wave length. This new schedule is effective through April, 1955.

MOON PHASES AND DISTANCE

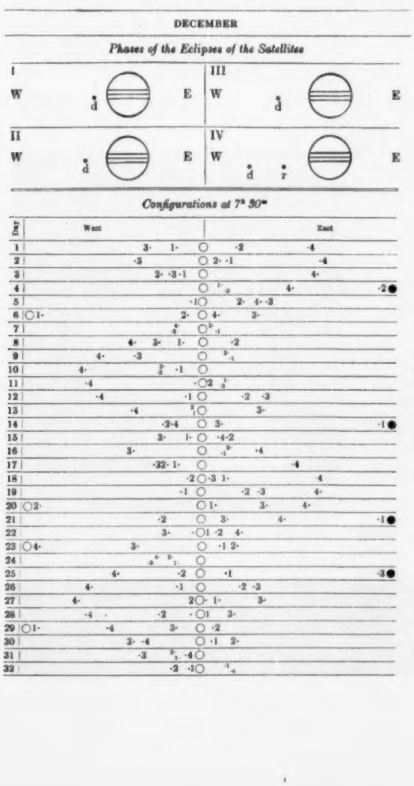
First quarter	December 3,	9:56
Full moon	December 10,	0:56
Last quarter	December 17,	2:21
New moon	December 25,	7:33
First quarter	January 1,	20:29

	December	Distance	Diameter
Perigee	9, 2^h	222,700 mi.	33′ 20″
Apogee	21, 9^h	252,200 mi.	29′ 27″
	January		
Perigee	6, 9^h	225,600 mi.	32′ 55″

JUPITER'S SATELLITES

The configurations of Jupiter's four bright moons are shown below, as seen in an astronomical or inverting telescope, with north at the bottom and east at the right. In the upper part, *d* is the point of disappearance of the satellite in Jupiter's shadow; *r* is the point of reappearance.

In the lower section, the moons have the positions shown for the Universal time given. The motion of each satellite is from the dot to the number designating it. Transits over Jupiter's disk are shown by open circles at the left, eclipses and occultations by black disks at the right. The chart is from the ***American Ephemeris and Nautical Almanac.***



FINDING VENUS BY DAY

This ephemeris continues that first presented on page 353 of the August issue, where Franklin J. Miller, Jr., gave a detailed explanation.

δ Aquarii, 3.5; December 1, 15:55, N; 2, 15:55, N; 3, 15:55, N; 4, 15:55, N; 5, 15:56, N; 6, 15:56, N; 7, 15:57, N; 8, 15:58, N; 9, 15:59, N; 10, 16:00, N; 11, 16:01, N; 12, 16:02, N; 13, 16.03, N; 14, 16:05, N; 15, 16:07, N; 16, 16:08, N; 17, 16:10, N; 18, 16:12, N; 19, 16:14, N; 20, 16:16, N; 21, 16:19, N; 22, 16:21, N; 23, 16:23, N.

Sirius, −1.6; December 24, 8:36, N; 25, 8:39, N; 26, 8:42, N; 27, 8:44, N; 28, 8:47, N; 29, 8:50, N; 30, 8:53, N; 31, 8:56, N. January 1, 8:59, N; 2, 9:03, N; 3, 9:06, N; 4, 9:09, N; 5, 9:12, N; 6, 9:16, N.

Example: Locate Delta Aquarii, magnitude 3.5, at any time during the early evening of December 1st, and line it up with some terrestrial landmark. Add 15 hours 55 minutes to the time of the observation, and use the same landmark to look for Venus the following day. If your evening observation is made at 8:32 p.m., Venus should be in the same place in the sky at 12:27 p.m. on December 2nd. The difference in declination between the selected finder stars and Venus will always be less than about two degrees. In the list, N means that Venus will be slightly to the north of the star; S that it will be slightly to the south.

MINIMA OF ALGOL

December 1, 18:47; 4, 15:35; 7, 12:24; 10, 9:13; 13, 6:02; 16, 2:51; 18, 23:41; 21, 20:30; 24, 17:19; 27, 14:08; 30, 10:57. January 2, 7:46; 5, 4:35; 8, 1:25.

These minima predictions for Algol are based on the formula in the 1953 ***International Supplement*** of the Cracow Observatory. The times given are geocentric; they can be compared directly with observed times of least brightness.

VARIABLE STAR MAXIMA

December 4, T Aquarii, 204**405,** 7.9; 5, R Trianguli, 023133, 6.3; 7, U Ceti, 0228**13,** 7.5; 9, S Carinae, 100**661,** 5.7; 15, T Centauri, 1336**33,** 6.1; 22, RT Cygni, 194048, 7.4; 24, RS Scorpii, 164**844,** 6.8; 29, S Sculptoris, 001**032,** 6.8.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted magnitude.

UNITRON Leads in Value and Quality

4" EQUATORIAL ($196 Down) **$785**

4" ALTAZ. ($116 Down) **$465** 3" ($66 Down) **$265**

4" PHOTO-EQUAT. ($222) **$890** 3" ($137) **$550**

An EXPERIMENT or an INVESTMENT?

The purchase of a cheap, inadequate telescope with poor optics and unstable mounting can prove to be a costly **experiment.** Such a telescope is frustrating to use and discourages progress. Before long, you will want to replace it with an instrument worthy of the time and effort you devote to observing. You will then be faced with the problem of disposing of an instrument with little or no market value.

On the other hand, the purchase of even the smallest UNITRON is an **investment** in an instrument constructed to give a lifetime of satisfying performance. Should you later wish to graduate to a larger model, you may easily find a buyer for your smaller telescope or use our trade-in plan. The value of your investment is protected by the UNITRON reputation.

Note these UNITRON features!

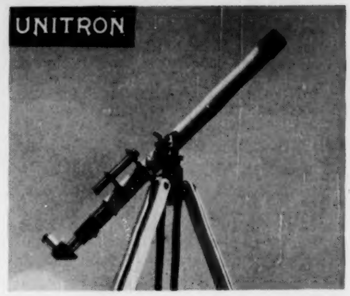
- LENSES are FULLY CORRECTED for spherical and chromatic aberration and are COATED for maximum brilliance and clarity of image. AIR-SPACED CELL insures freedom from "clouding" with age.
- EYEPIECES of the HIGHEST QUALITY: Orthoscopic, Achromatized symmetrical, Kellner, Huygens.
- FINEST MATERIALS used throughout. DURALUMINUM TUBE. Moving parts of BRASS carefully machined to close tolerances, and finished in CHROMIUM.
- MODERN DESIGN based on time-tested engineering principles. HANDSOME APPEARANCE to which no illustrations can do justice.
- STURDY TRIPOD may be folded for convenient storage.
- EQUATORIAL MODELS have slow-motion controls for **both** declination and right ascension.
- ALTAZIMUTH MODELS have slow-motion controls for **both** altitude and azimuth.
- VIEW FINDER with crosshair eyepiece gives wide field of view.
- RACK-AND-PINION FOCUSING.
- PRISMATIC STAR DIAGONAL for convenience in observing at all altitudes.
- SUNGLASS for solar observation.
- ERECTING PRISM SYSTEM for TERRESTRIAL OBSERVATION may be used with **any** of the eyepieces to give the **same** complete range of terrestrial magnifications as for celestial observation.
- FITTED WOODEN CABINET, handsomely finished, for compact storage of telescope and accessories. Tripod case.

All Instruments Fully Guaranteed

Send check or m. o. or 25% deposit, balance C.O.D. Shipment express collect.

USE OUR EASY PAYMENT PLAN
See page 73 for details

FREE CATALOG AVAILABLE
See the outside back cover



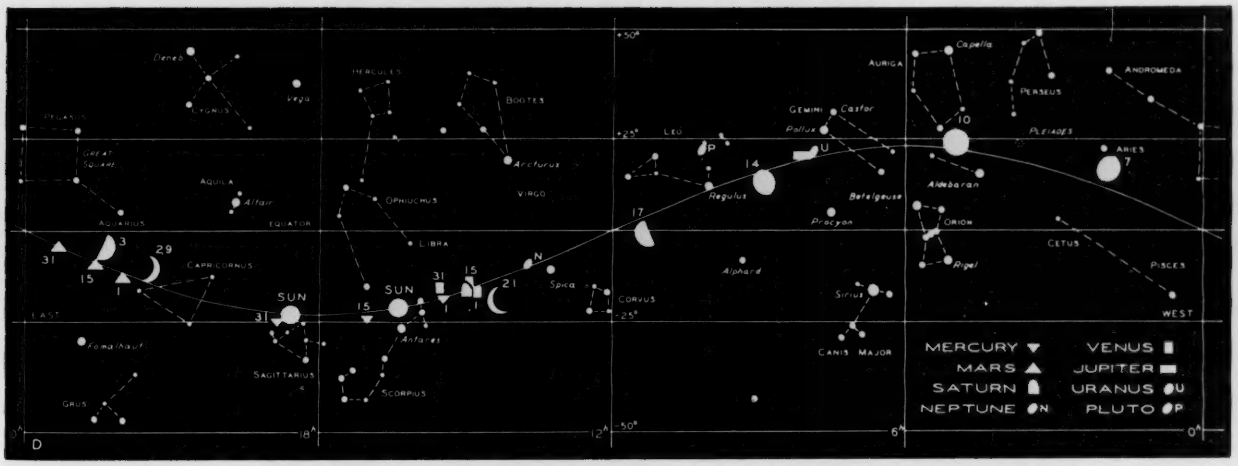
1.6" ALTAZIMUTH ($19 Down) **$75**

2.4" ALTAZIMUTH ($31 Down) **$125**

2.4" EQUATORIAL ($56 Down) **$225**

3" EQUATORIAL ($108 Down) **$435**

United Scientific Co. 204-206 MILK STREET, BOSTON 9, MASS.



THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month and for other dates shown.

Sun. The last of the five eclipses this year and the second to be annular occurs on December 25th. Its path begins in the South Atlantic Ocean, crosses South Africa, the Indian Ocean, and ends in Indonesia. Greatest duration of the annular phase is 7 minutes 39.6 seconds, over the Indian Ocean.

Mercury may be viewed in the morning sky during the first week of December. On the 4th it rises an hour before the sun, appearing at magnitude −0.6. Superior conjunction with the sun occurs on the 25th, when Mercury enters the evening sky.

Venus attains greatest brilliance in the morning sky on December 21st, dazzling white and of magnitude −4.4, practically the brightest this planet can be, when it can cast shadows. The moon will be in conjunction with Venus at 19^h UT on this date, 7° 20′ south of the planet, and will aid in finding Venus in the daytime. Telescopically, the planet will then be a crescent 41″ in diameter, with 26 per cent of the area of the disk illuminated.

Earth arrives at heliocentric longitude 90° on December 22nd at 09:25 UT. Winter begins in the Northern Hemisphere and summer in the Southern.

Mars travels across Aquarius in December, continuing to fade; in midmonth it is of magnitude +0.7. The planet is on the meridian shortly after sunset, setting 5½ hours later.

Jupiter, in retrograde or westward motion in western Cancer, rises as evening twilight disappears by the end of the month. As happens every 12 years, there was no opposition of Jupiter in 1954; the coming opposition will occur on January 15, 1955. At the end of December, when Jupiter has a magnitude of −2.2, it presents a disk 46″ in equatorial diameter.

Saturn remains close to Venus all month, and is overshadowed by its brilliance. A fairly close conjunction takes place December 16th, when Venus passes 39′ north (see the November issue, page 33). Saturn is of magnitude +0.8 in December, and in a telescope the rings present their northern face, tilted 21°.5 to our view on the 20th.

Uranus will be about ½° west of Jupiter at the end of the month. This 6th-magnitude object is also in retrograde motion.

Neptune, in the morning sky, rises about 2 a.m. local time. About 5° east of Spica, 8th-magnitude Neptune is moving eastward.

E. O.

UNIVERSAL TIME (UT)

TIMES used on the Observer's Page are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, in which case the result is your standard time on the day preceding the Greenwich date shown.

OCCULTATION PREDICTIONS

December 3-4 **Kappa Piscium** 4.9, 23:24.6 +1-00.2, 9, Im: **I** 7:37.1 ...... 138.

December 7-8 **Zeta Arietis** 5.0, 3:12.3 +20-52.5, 13, Im: **B** 8:52.9 ...... 163.

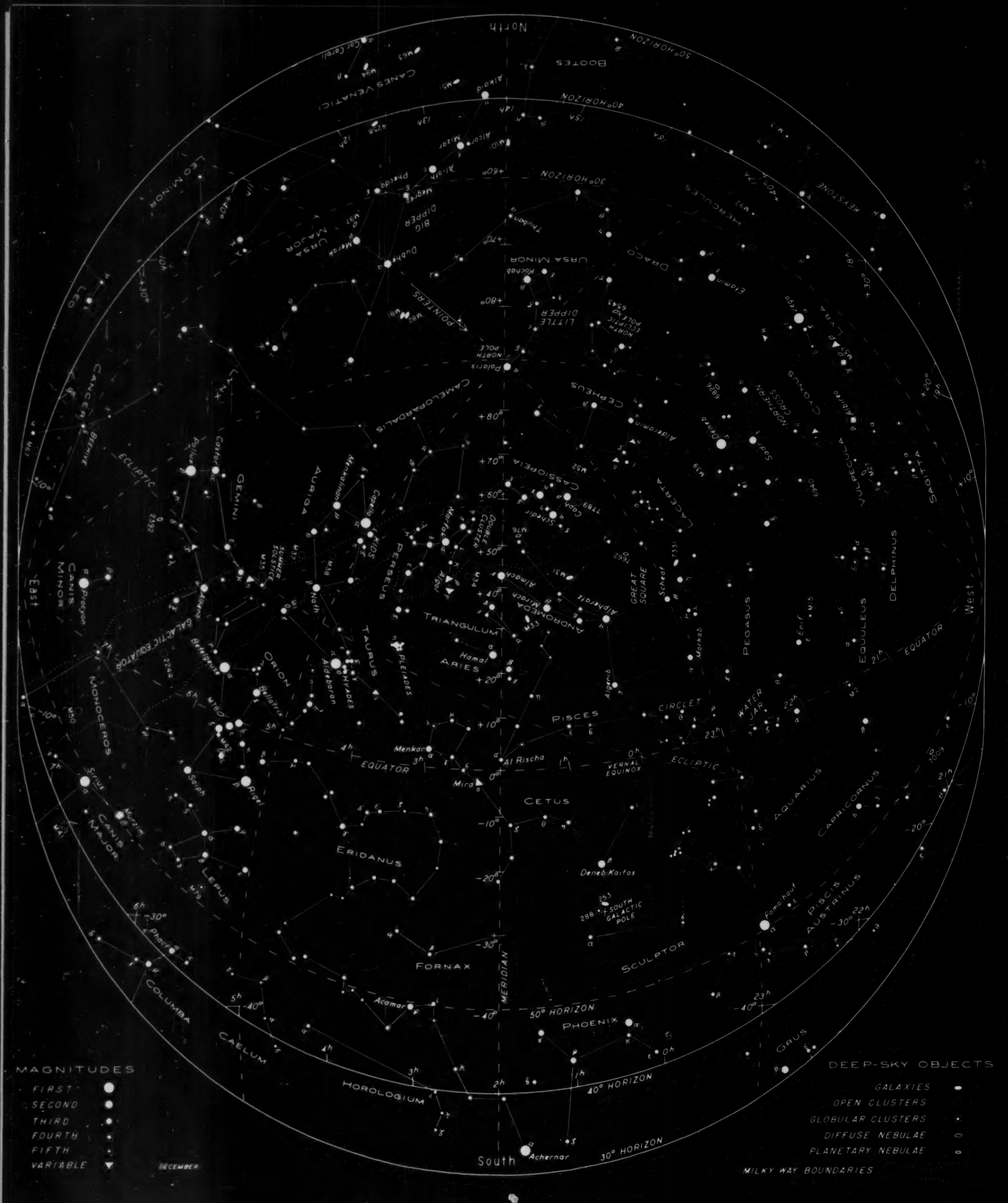
December 11-12 **g Geminorum** 5.0, 7:43.5 +18-37.4, 17, Em: **I** 14:29.3 −1.4 −0.4 236.

For stations in the United States and Canada, usually for stars of magnitude 5.0 or brighter, data from the **American Ephemeris** and the **British Nautical Almanac** are given here, as follows: evening-morning date, star name, magnitude, right ascension in hours and minutes, declination in degrees and minutes, moon's age in days, immersion or emersion; standard station designation, UT, **a** and **b** quantities in minutes, position angle on the moon's limb; the same data for each standard station westward.

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude, respectively, enabling computation of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the difference in longitude (**Lo — LoS**), and multiply **b** by the difference in latitude (**L — LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your standard time.

Longitudes and latitudes of standard stations are:

A	+72°.5,	+42°.5	**E**	+91°.0,	+40°.0
B	+73°.6,	+45°.5	**F**	+98°.0,	+31°.0
C	+77°.1,	+38°.9	**G**	Discontinued	
D	+79°.4,	+43°.7	**H**	+120°.0,	+36°.0
			I	+123°.1,	+49°.5



STARS FOR DECEMBER

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of December, respectively; also, at 7 p.m. and 6 p.m. on January 7th and 23rd. For other dates, add or subtract ½ hour per week.

The beginner who wants to learn the constellations will find it easy to start with Orion in the southeast. A compact row of three bright stars is flanked by brilliant Betelgeuse and Rigel. This row, Orion's belt, points up the sky to Aldebaran and downward to Sirius.

Spitz Jr. Planetarium

No. 701 Spitz Junior Planetarium. A new visual teaching aid brings a knowledge of the heavens into your classroom or home. A plastic globe is perforated with small apertures and contains a pinpoint light source inside. Stars and constellations are projected on the ceiling; a dome is helpful, but not necessary. Adjustable for date and latitude. Size: 14½" high, 7½" square base. Weight 3 lbs. Operates on 110-volts. Complete with 32-page star guide. **Postpaid $15.00**

Celestial Globes

No. 732 Little Dipper Globe. A teaching aid that is designed to introduce the wonders of the heavens to all youngsters, and it will fascinate grownups too. The all-metal six-inch celestial globe emphasizes the mythological background of the constellations in five brilliant colors and shows all major stars and constellations, the equator and the ecliptic. A meridian circle and a convenient base are included. Popular 155-page book "Stars" in full color is included to give further material on the mysteries of astronomy. Overall height 8½"; shipping weight 2½ lbs. **$3.95**

No. 731 Celestial Globe. This full 9" diameter globe has an attractive base and setting that makes it ideal for display in the school-room or home. A dark blue background makes the yellow stars stand out for easy recognition. Stars to the sixth magnitude included. Ecliptic and equator emphasized. Constellation outlines and mythological figures in light blue. Movable meridian for latitude. Brown plastic cradle supplies horizon as well as effective base. With handbook. **$14.50**

No. 740 Deluxe Celestial Globe. Our finest 16" globe was designed as a visual aid by teaching astronomers. All stars of the first six magnitudes are shown on a pale blue background, with the first three magnitudes having bright yellow circular backgrounds. Brighter stars named and constellation boundaries indicated. Declination and right ascension circles printed in black. Magellanic Clouds and Milky Way stand out in white, with important star clusters indicated.

740-1	Plain low table base (Illus.)	**$49.50**
740-5	Weighted table base, movable meridian with horizon	**67.50**
740-5d	Weighted floor base, movable meridian with horizon	**75.75**

SCIENCE ASSOCIATES

401 North Broad Street **Philadelphia 8, Pa.**

See pages 73 and 80 for prices, terms, and photographs of UNITRON Refractors.